MECHANICAL DRAWING

FIRST YEAR

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INTRODUCTION

First Semester.

In planning this course of Mechanical Drawing lessons the authors have realized the difficulty of satisfying the many different theories of how the subject should be taught.

Simply stated, their aim has been first, to develop the technical skill of the student, and second, to train him to visualize and reproduce simple objects by drawings.

In order to interest as many students as possible the objects drawn cover a rather wide range. Each principle or type of work is immediately applied in the required plates which follow the description of the new work. A large number of supplementary problems permits the instructor to vary the course to suit his own particular needs.

While many teachers object to spending any time on geometrical constructions, it has been felt that these are the basis of rapid and accurate work, and that if they are presented to the student in the form of interesting applications, he will see their value as well as appreciate the possibilities of his instruments.

Mechanical Drawing is a mathematical subject and the pupil should learn to think and talk accurately from the start. It is therefore urged that the pupil be drilled on the use of those words and definitions which are peculiar to the subject and which he will neglect unless he is required by his teacher to use them.

The word tests on pages 15 and 16 are intended to help fix the meaning of new words and definitions so that the pupil will not have to admit that he knows a fact but cannot express it.

How to get the pupil to do good lettering is an important and difficult problem for the teacher. Important because more drawings are spoiled by poor lettering than by any other one thing. Difficult because it is hard to get the pupil to practice as long and faithfully as he should. At first he does not see the need for such painstaking effort and it is the teacher's duty to show him how essential good lettering is.

It is often an incentive to let the student see

the difference between a good drawing with no letters and figures on it, and the same drawing when it is lettered poorly, and also when lettered in a first class manner. If this demonstration is followed by showing him samples of drawings and blueprints from well known concerns, he will see what is demanded of him, and the word "practice" will not be so hateful to him.

THE AUTHORS.

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OUTLINE OF WORK FOR FIRST SEMESTER

The following outline, to cover five, 45 minute periods a week has proved satisfactory and is suggested for trial when first using the course. For periods of different length or frequency the course is sufficiently flexible to allow of easy adjustment to suit the case.

		Page
1.	Study of the alphabet and drill in lettering	10-13
2.	Talks on definitions of lines and geometrical forms	14-15
3.	Demonstration of use of instruments and explanation of Mechanical Drawing	18-28
4.	Draw Plate 1 using the actual models found on loose sheet	23
5.	Selected problems from Plates 1, 2, 4, 6, 8, all in pencil	23-40
6.	Method of inking a drawing explained, followed by test problem	25
7.	Ink Plates 3, 5, 7, 9	32-41
8.	Shop problems from Plate 10 or Plates 11 and 12	42-45
9.	Study geometric constructions and their applications	46-50

MECHANICAL DRAWING

DRAWING MATERIAL EVERY PUPIL SHOULD HAVE.

1—Instruction book.
2—Set of instruments.
3—Drawing board, 20″ x 24″.
4—T-square, 24″.
5—Two triangles (celluloid preferred) 45° and 30°60°.
6—12 inch architect's scale.
7—Thumb tacks.
8—4-H pencil and sandpaper pencil sharpener.
9—Eraser and art gum.
10—Penholder and pens.
11—Drawing paper (good grade) 11″ x 15″ or any size the teacher may specify.
12—Lettering tablets ruled for 3/8″ and 3/16″ letters.
13—Black drawing ink.

Drawing paper comes in rolls or sheets and is known as Hot Pressed, Cold Pressed or Rough. Hot Pressed paper has a glossy surface and is used for fine line drawings. Cold Pressed shows a slightly coarser grain and is used for either ink or color work, while Rough paper has a very coarse open grain best adapted for soft pencil sketching and water color.

When paper comes in rolls, the rolls are cut to standard widths as 30″, 32″, 36″ or 40″ rolls; 10, 20 or 24 yards to the roll.

When in sheets the following commercial sizes are most used:

COMMERCIAL SIZE SHEETS.	
NAME.	DIMENSIONS
DOUBLE ELEPHANT.	27″ x 40″
SPECIAL.	24″ x 36″
IMPERIAL.	22″ x 30″
ROYAL.	19″ x 24″
MEDIUM.	17″ x 22″
DEMY.	15″ x 20″
CAP.	14″ x 17″

SUBDIVISIONS OF IMPERIAL SHEET.		
DIVISION.	OUTSIDE DIMENSIONS.	BORDER LINE DIMENSIONS
WHOLE SHEET.	22″ x 30″	20″ x 27″
HALF "	15″ x 22″	13″ x 19″
QUARTER "	11″ x 15″	10″ x 13″
EIGHTH "	7½″ x 11″	7″ x 10″

Sizes and Subdivisions of Drawing-Paper Sheets.

Note:—The size of sheet recommended is 11″ x 15″ and all the drawings in the following lessons will fit on the sheet as shown in the various plates.

Sometimes it may be advisable to put only one or two drawings on a plate in which case the size of the object may be doubled.

For this course cream or buff colored drawing paper is suggested, particularly for pencil work.

It is assumed that the set of instruments such as compass, dividers, ruling pen, etc., is either furnished by the school authorities or specified by the instructor, hence they are not described here.

The average instructor generally demonstrates before the class the method of fastening paper to the board, drawing borders, etc., so that the advice on Page 18 "Before beginning to Draw," with the demonstration, is in most cases sufficient to start a class properly.

WHAT DETERMINES A GRADE IN MECHANICAL DRAWING.

The successful draftsman and drafting student are very painstaking and careful of little things. To give a student some idea of the proper standards for his work, a marking scheme is here given.

S (95-100) is the reward for extra fine work, showing originality or ability to do one's own thinking, and ambition to do more than the course requires.

E (90-95) is given when the drawings are correct, well-placed, and stand out clear; that is, they follow the standard lines and conventions, and the lettering looks neat and regular.

G (80-90) is given to the average student who keeps up to the schedule, but is not willing or is unable to make his work look neat and accurate.

F (75-80) is given to the student who needs constant attention and pushing; who is slow in getting started. He hands in work that is not complete; he does not care how his work looks, so long as he passes.

D (below 75) means that the student has failed in his work, seldom from the lack of ability, but rather from the lack of interest and from laziness. He often draws with the stub of a dull lead pencil, and his instruments are caked with dirt and are rusty. He may have disturbed the class by talking, borrowing, and leaving his place. Good conduct, study and obedience to the rules of the drafting room will lead him to success.

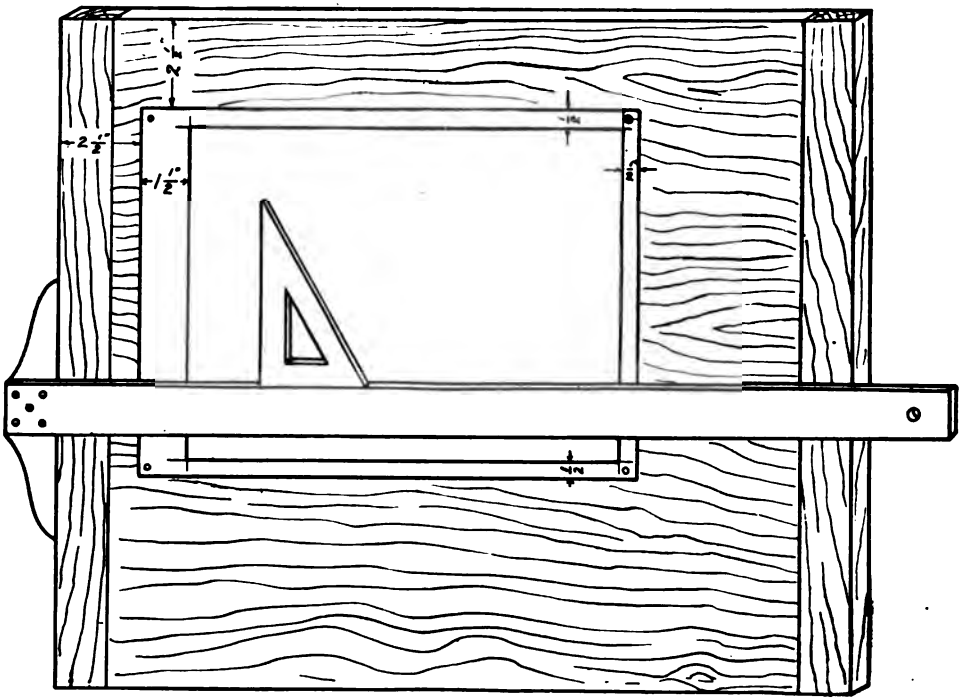


Fig. 1.

LETTERING.*

Two kinds of lettering are used in Mechanical Drawing: the Vertical Gothic and the Slant Gothic,† and a good draftsman should be able to use either style as may be required.

The beginner must go slowly at first until he knows the shape of the letters and until he has his fingers under good muscular control. Horizontal guide lines are always necessary and at first vertical or slant lines must be drawn, for nothing looks worse than to make letters of different heights and different slants.

The height of the first practice letters made is optional though it is common to make them at least 3/8" high, requiring later practice to be of the smaller size ordinarily used for notes and other lettering required on a drawing.

Next fix in mind the proper width of the letters which in this simple form of alphabet is usually made in the ratio of three to four as shown. (Fig. 2.)

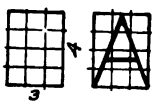


Fig. 2

There are three exceptions:—I which is only the width of a line, M which fits in a square, and W which is a little wider than it is high.

Note: When using small letters see that the guide lines are spaced like the sample. (Fig. 3.)

Also notice how fractions are made.

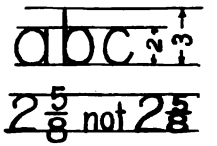


Fig. 3

When lettering a sentence see that the letters are close together, but the words well separated.

It is suggested that lettering be taught in short frequent assignments on small lettering tablets rather than by requiring longer exercises. Any small, ruled lettering tablet, or a 11" x 15" drawing plate, cut into eight pieces each 3¾" x 5½", may be used.

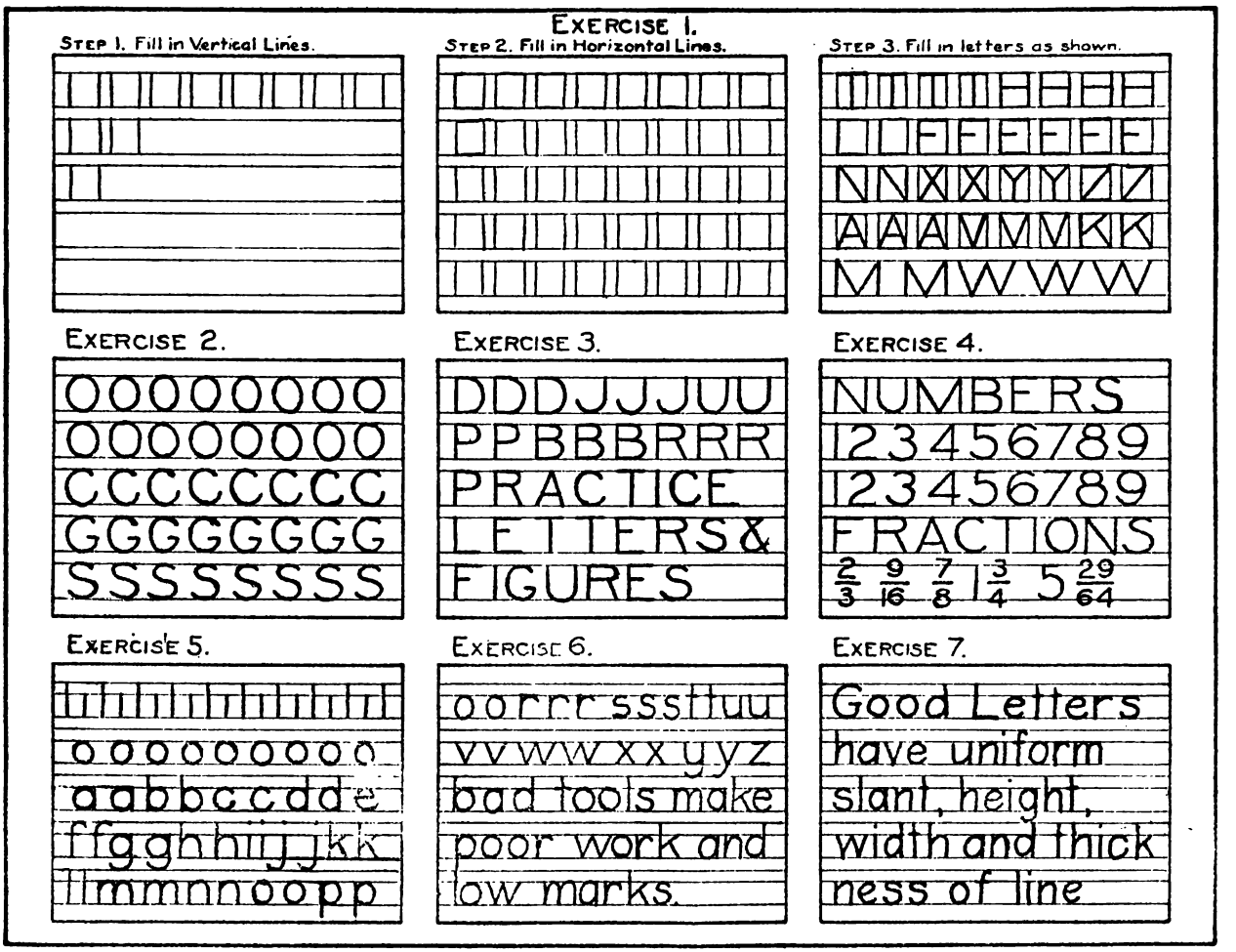
On the opposite page the beginning exercise is shown in three successive steps, and only one sheet of paper is required.

If lettering is to be inked use a Gillott No. 303, or an Esterbrook No. 521, or any other fine, stiff pen, as inked letters are not shaded.

Be sure to fasten the small alphabet sheet inserted in the middle of this book, at the top of your drawing board.

*Read also the paragraphs on Slant Gothic Lettering.
†The teacher will state which style is to be learned.

VERTICAL LETTERING EXERCISES



SLANT GOTHIC LETTERING.

The rules on Page 10 for the vertical lettering style also apply to slant lettering. For this style note:

First.—All the letters must have the same slant. This slant is easily found by making a right angle triangle with the proportion three to eight, as shown. (Fig. 4.) At first slant lines will have to be drawn on each exercise sheet until the right direction is finally fixed in the mind.

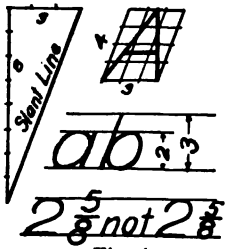


Fig. 4

Second.—The width of the letters is ¾ of the height. See sample. (Fig. 4.) There are three exceptions: I which has only the thickness of a line, M which has the same width as height, and W which is a little wider than it is high.

Notice that in the letters A, V, W and Y the slant line runs through the middle of the letter. The right side of A and the left side of V and W are practically vertical. When making small letters see that the guide lines are spaced as shown.

Notice how fractions are made. (Fig 4.)

Caution:—Use light lines so that mistakes can easily be erased. Do not pinch the pencil as your hand soon tires. Hold it as illustrated in Fig. 5.

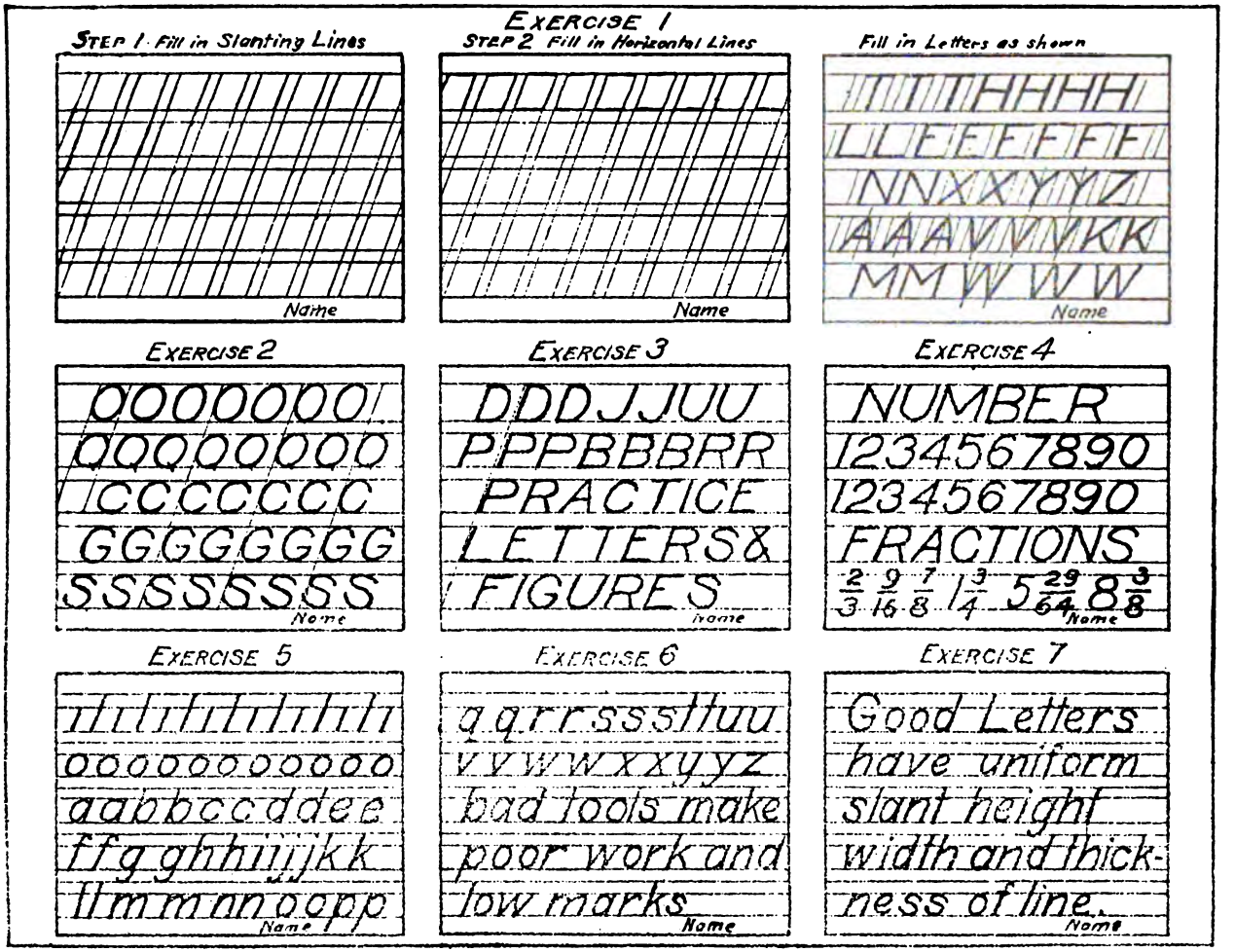

Fig. 5

The size of the first letters made is optional, but it is strongly recommended that small exercise sheets be used instead of large lettering plates which tend to waste time and discourage the pupil.

It will be well to letter in pencil only, until you can do it neatly and with fair speed. Your first inking of letters should be done over penciled exercises as only the very skilful can letter with pen and ink directly. In all cases when inking letters use guide lines as when penciling.

Be sure and fasten the little alphabet sheet to the top of your drawing board. These are the only letters, lines and figures you will be allowed to use.

SLANT LETTERING EXERCISES



SOME COMMON WORDS USED IN MECHANICAL DRAWING AND THEIR DEFINITIONS.

Lines.

Horizontal—A line that is level or parallel to the horizon.

Vertical—A line that is at right angles to the horizontal or parallel to a plumb line.

Parallel—Lines that are always the same distance apart.

Perpendicular—Lines or surfaces that are at right angles to each other.

Perpendicular does not necessarily mean vertical.

The word "straight" never tells in what direction a line points.

Angles.

Angles are measured by degrees. There are 360 degrees in every complete circle.

Right Angle—A square corner or an angle having 90 degrees.

Acute Angle—An angle less than a right angle.

Obtuse Angle—An angle greater than a right angle.

Circles.

Circle—A curved line, every part of which is equidistant from a given point, called the center.

A circle is divided into 360 degrees and contains four right angles at its center. The distance around a circle is called the **circumference.**

Semi-circle—Half a circle, or 180 degrees.

Arc—Part of a circumference.

Diameter—Any straight line passing through the center of a circle, from side to side.

Radius—Distance from center to circumference.

Tangent—Any straight line that touches a circle at one point. It is always perpendicular to a radius drawn to that point.

Straight Line Figures.

Polygon—A figure that has any number of sides.

Right-angled Triangle—A triangle one of whose angles is a right angle.

Equilateral Triangle—A triangle which has three equal sides.

Square—A figure which has four equal sides and four right angles.

Rectangle—A figure whose opposite sides are equal and parallel and whose angles are right angles.

Parallelogram—A four sided figure whose opposite sides are equal and parallel.

Solids.

Sphere—A solid bounded by a curved surface every point of which is equally distant from a point within called the center.

Cube—A solid bounded by six square sides.

Cylinder—A solid bounded by a curved surface and two opposite faces called bases.

Cone—A solid, one of whose surfaces tapers to a point and whose base is a closed curve.

Prism—A solid having ends which are polygons of the same size and shape and connected by edges which are parallel.

Pyramid—A solid whose base is a polygon and whose faces are triangles meeting at a common point.

Truncated cone, pyramid, or prism—That section that is left after the upper part has been cut off.

WORD TEST.

Questions on the direction of lines and the shapes of plane surfaces and solids.

1. Tell whether the following objects are horizontal, vertical, inclined or perpendicular.

Flag pole ( ), floating plank ( ), window ( ), coal chute ( ), desk top ( ), T-square head and blade ( ).

2. When is the hour hand of a clock vertical? When is it horizontal? When do the two hands make an angle of 30° ? When do they make an angle of 45° ? How many degrees are there between 5 o'clock and 7 o'clock?

3. Which circle has the greater number of degrees in its circumference, a one inch or a one foot circle?

If a pie is cut into five equal parts how many degrees are there in each part?

4. How many sides have the following figures? Square ( ), Hexagon ( ), Rectangle ( ), Octagon ( ). What shape is the side of a square prism? What shape is the side of a triangular prism? What shape is the side of a hexagonal pyramid? What shape is the side of a rectangular pyramid?

5. In what two shapes are lead pencils made? What is the shape of a brick? What is the shape of a ball-bearing? What is the shape of a tin funnel? What is the shape of a dice?

6. What shapes have the bases of the following solids? Cylinder ( ), hexagonal pyramid ( ), octagonal prism ( ).

7. What shapes have the cross sections of the following objects? An orange ( ), a cylinder cut perpendicular to the axis ( ), a cone cut in line with the axis ( ). An hexagonal pyramid cut parallel to the base? A 2 x 4 timber cut square across the grain? A cylinder cut at an angle to the axis?

WORD TEST.

Complete the sentences, using the right words.

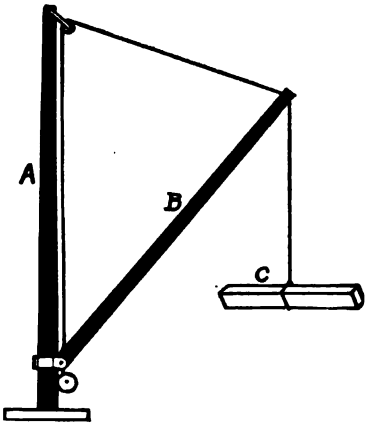


Fig. 6

The mast A is———.

The boom B forms an———with the mast.

The beam C is suspended in a———position.

The mast and the rope beside it are———to each other.

The handle of the rake is———and———to the head.

The teeth are———to each other.

Correct this statement: The head of the rake is fastened on straight.

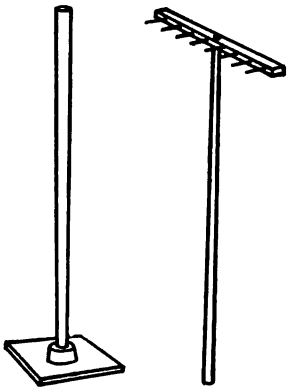


Fig. 7 Fig. 8

In the concrete tamper what is the relation of the handle to the face of the plate?

How does the handle usually stand?

Describe a wheelbarrow, mentioning the following facts:

1. The relation of the handles to each other and to the ground.

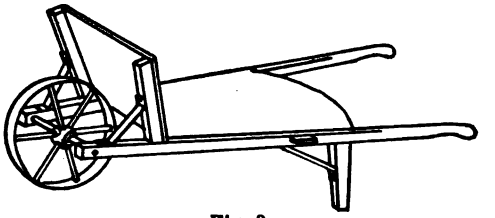


Fig. 9

2. The relation of the legs to the handles.

3. How the wheel stands, and the relation of the wheel to the axle.

4. There are six spokes. Describe the angles between them.

Describe the relation of the wheel to the axle and to the steel rail. (Fig. 10.)

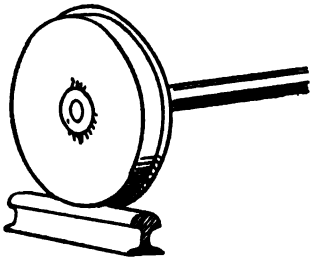


Fig. 10

How would you state that the wheel is 3 feet across; that the distance around the outside is about 9 feet, and the distance from the center to the outside is 1½ feet?

The tin cup is —— in shape.

Fig. 11.

The nut is shaped like a —— —— and has a —— hole through it.

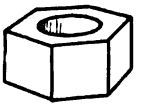


Fig. 12.

Write the names of the following solids:—

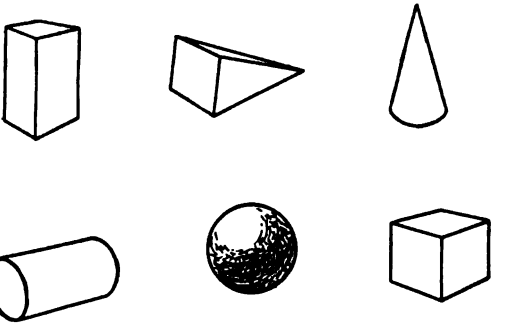


Fig. 13.

For correct answers see pages 14 and 15.

BEFORE BEGINNING TO DRAW.

Be sure:—

1. That the left-hand edge of your board is straight.
2. That your T-square is rigid and has a smooth edge.
3. That your triangles, scales, and hands are clean.
4. That your 4-H pencil is sharpened as shown. (Fig. 14.) Your teacher will tell you which style of point to use.
5. That the lead in your compass is 4-H and is sharpened to a fine, round point.

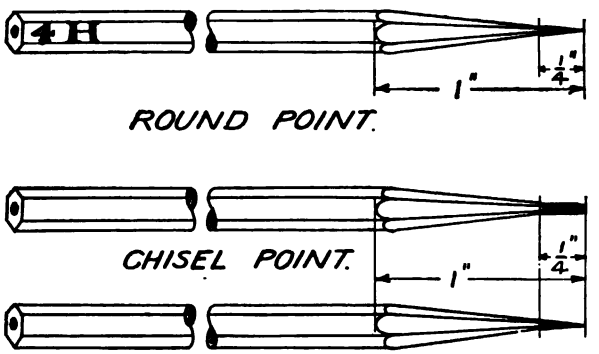


Fig. 14.

When these five important directions have been complied with, you can fasten the paper on the board near the upper left hand corner as shown in (Fig 1.) This will give you plenty of room to rest your hand on the board when you are drawing near the bottom edge of the paper.

Border Lines. First notice how far they are from the edges of the paper, then with the T-square held tightly against the left edge of the board draw the top and bottom lines, after which, using the triangle as shown, draw the right and left hand border lines.

Caution:—Always use light pencil lines, letting them cross a short way as that will help to make clean sharp corners when inking. (Fig. 15.)

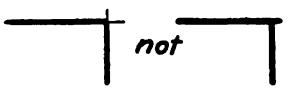
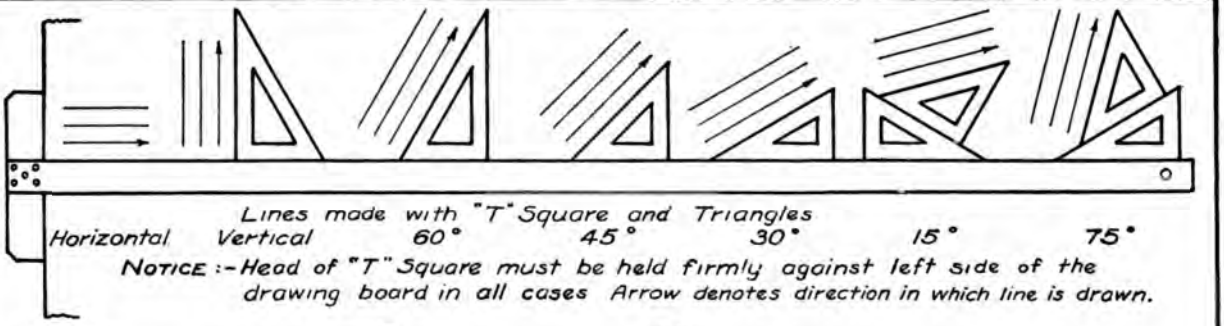


Fig. 15.

RULES OF THE DRAFTING ROOM.

1—Don't **talk.**
2—Don't **borrow.**
3—When in difficulty ask your teacher.
4—Stay in your place until time to pass.
5—Don't make excuses—**make good.**

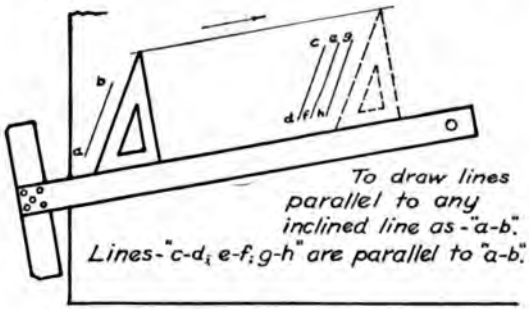
METHODS OF DRAWING STRAIGHT LINES AND ANGLES. DATA SHEET.



Lines made with "T" Square and Triangles

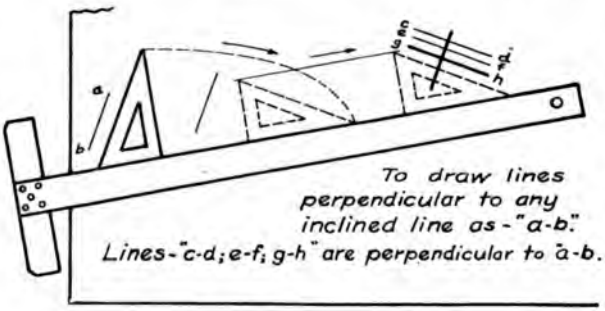
Horizontal Vertical 60° 45° 30° 15° 75°

NOTICE :- Head of "T" Square must be held firmly against left side of the drawing board in all cases Arrow denotes direction in which line is drawn.



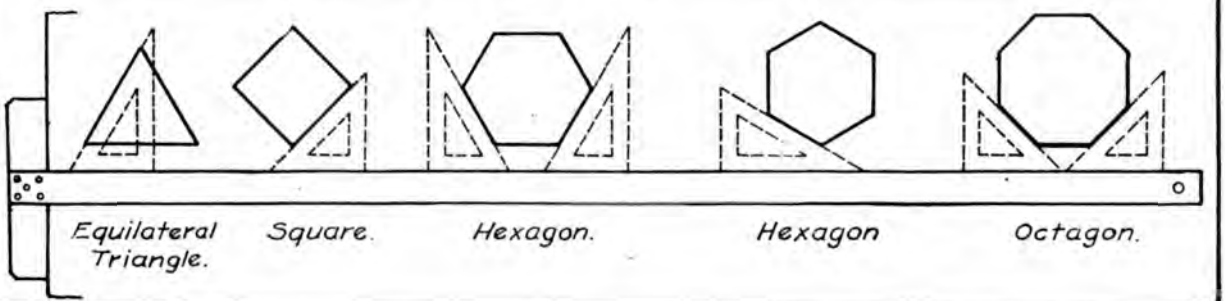
To draw lines parallel to any inclined line as - "a-b".

Lines - "c-d; e-f; g-h" are parallel to "a-b".



To draw lines perpendicular to any inclined line as - "a-b".

Lines - "c-d; e-f; g-h" are perpendicular to "a-b.



Equilateral Triangle. Square. Hexagon. Hexagon Octagon.

WHAT MECHANICAL DRAWING MEANS.

There are two methods of representing an object. First, when viewed from one point only, (Fig. 16); second, as it appears when viewed from points directly opposite it, (Fig. 17). The first method is called Perspective Drawing, and is useful in showing an object as it naturally appears to the eye. The length, breadth, thickness and form can usually be seen in one view but not in their true size and shape.

In the second method we see the true size and shape of but one side of the object at a time, so that only two of the three dimensions can be shown in a single view. Hence it is necessary to make at least two views of an object. Many things require three or more views to give one a clear conception of them.

These views are named according to the side they are directly opposite; viz, the top, or horizontal view, the front, and the side or end view.

The difficult thing to remember is that when we draw the top view for instance, we are looking down on the object as the boy is doing in the photograph in Fig. 19. In the same way the front and side views are viewed from points directly opposite the front and side vertical planes.

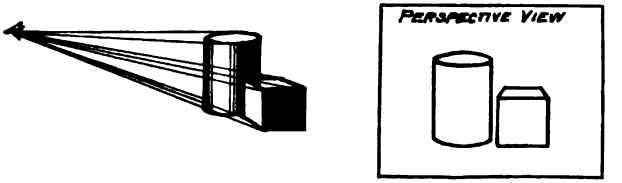


Fig. 16.

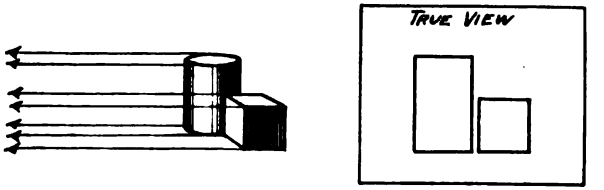


Fig. 17.

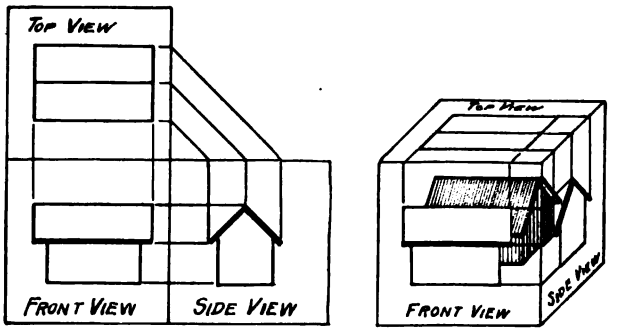


Fig. 18.

Fig. 10.

We now discover that these three views have certain dimensions in common and that with the aid of a T-square and triangles the views can be drawn much quicker and easier than if they were on separate sheets of paper (Fig. 19.)

It is understood that drawing on a paper box is only done to illustrate the principle of Projection Drawing and that the student must learn to imagine or visualize each problem according to the method just described.

In order to see all three views at once it is necessary to spread the paper box out flat on the drawing board. See Fig. 20.

Fig. 20.

DIRECTIONS FOR DRAWING PLATE 1.

The purpose of this plate is to show you how to make the Top, Front, and Side views of four simple objects whose names you should learn, as they are type solids.

On a loose sheet in the middle of the book is the outline for each object, which when cut out and folded together form actual models, which you are to study in the manner described on Pages 20 and 21.

If there is any difficulty about understanding the different views make a small box out of stiff paper. See Fig. 21, and use it as the boy is doing on Page 21. In any case always imagine that in each view you are looking squarely at the object as shown in Fig. 17, Page 20.

In Plate 1, Problem 1 is complete, but the other three problems need an additional view which can be easily obtained by projecting the proper lines across from the other two views.

Letter the corners of the objects to correspond with those of the paper models. See Problem 3. This is very important as it will show whether you understand the way in which the three views agree with each other.

When lettering the titles be sure to use light guide lines spaced exactly as shown. Also when

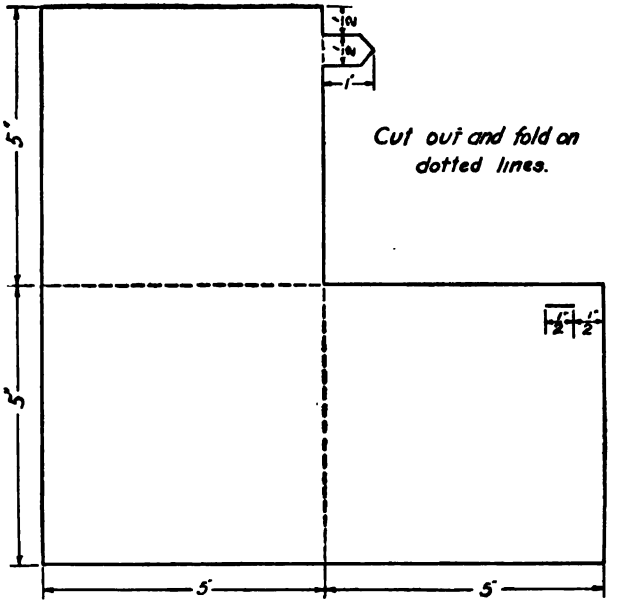


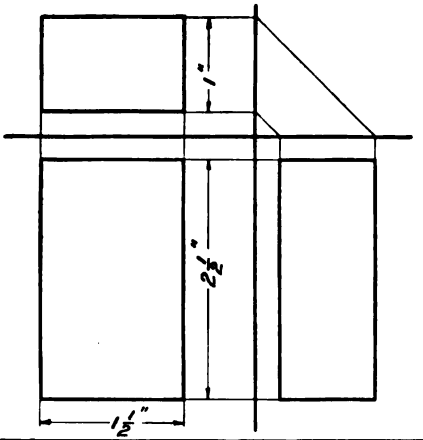
Fig. 21.

penciling the rest of the lines do it with fine light strokes so that mistakes can be easily erased. What difference do you see between the visible, hidden and projection lines? Notice how nicely each problem is located in the center of its allotted space.

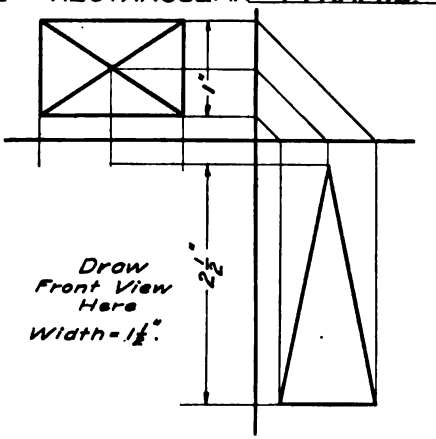
Before laying out a problem you should decide what views are needed and where each is to be placed on the sheet. The best way is to make

PLATE:- I.

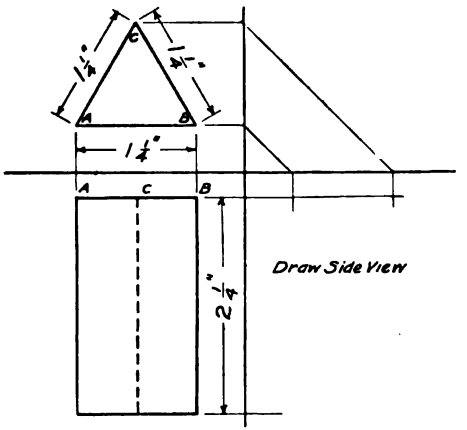
PROB.-1. RECTANGULAR PRISM.



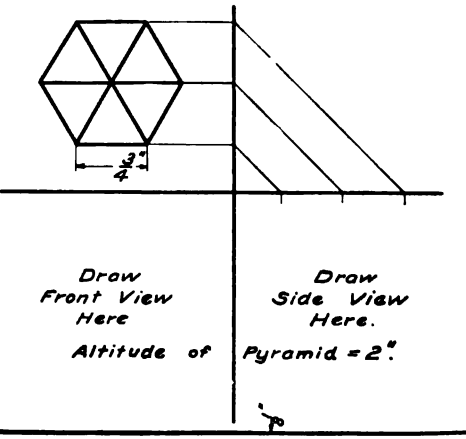
PROB.-2 RECTANGULAR PYRAMID.



PROB 3 EQUILATERAL TRIANGULAR PRISM



PROB.-4. HEXAGONAL PYRAMID.



PUPIL'S NAME.

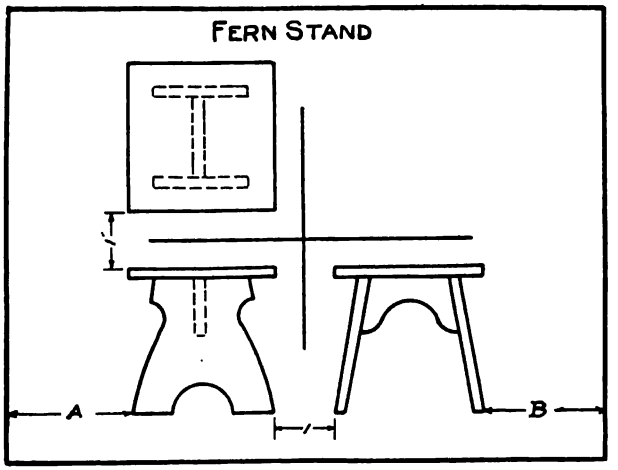


Fig. 22.

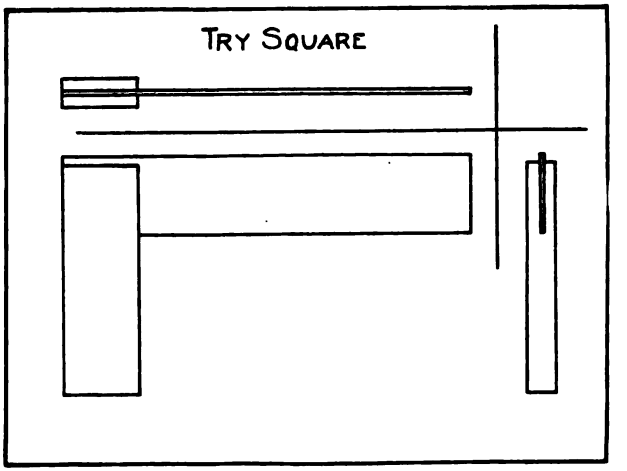


Fig. 23.

a small preliminary sketch showing how much room will be required for the separate views when arranged in the best manner.

See that the views are about one inch apart and equally distant from the border lines. Make spaces A and B in Fig. 22 equal.

In Fig. 22 we see the best layout of an object whose three dimensions are about the same and in Fig. 23 we see the best layout for a long flat object.

On Page 27, methods of showing dimensions are described and illustrated. Follow these carefully whenever placing dimensions upon your drawing.

Inking is a part of drafting work, often deferred until the student has gained the ability to make neat, accurate pencil drawings. Time will generally be saved by learning thoroughly one thing at a time, but as there may be some pupils ready to begin inking work on Plate 1, directions follow here.

Note:—Before inking a plate, the student should make in ink a good copy of the following sample, showing dimensions and exact in size and quality of lines. (Fig. 24). This will show his teacher whether he is ready to start on his regular plate. It is better to spoil several small test sheets than a full-sized drawing.

BEFORE COMMENCING TO INK.

Be sure:—

1. That the pencil drawing is correct and O. K.'d by the teacher.
2. That all mistakes are erased.
3. That your pen is properly sharpened so that it will make a thick or thin line as required.
4. That there is no ink on the outside of the ruling pen.

ORDER OF INKING A DRAWING.

1. Ink all center lines.
2. Circles, arcs, and irregular curves.
3. Horizontal solid lines, starting from the top of the drawing.
4. Vertical solid lines, starting from the left of the drawing. Then all oblique solid lines.
5. Horizontal hidden lines, starting from the top of the drawing.
6. Vertical hidden lines, starting from the left of the drawing, then all oblique hidden lines.
7. Projection, extension and dimension lines.
8. Dimensions, arrow heads, notes and title.

Border lines are inked in last.

Check the drawing before handing it to the instructor.

THREE IMPORTANT DON'TS.

1. Don't use a blotter on freshly-inked lines.
2. Don't scrub your drawing all over till the ink lines have lost their freshness.

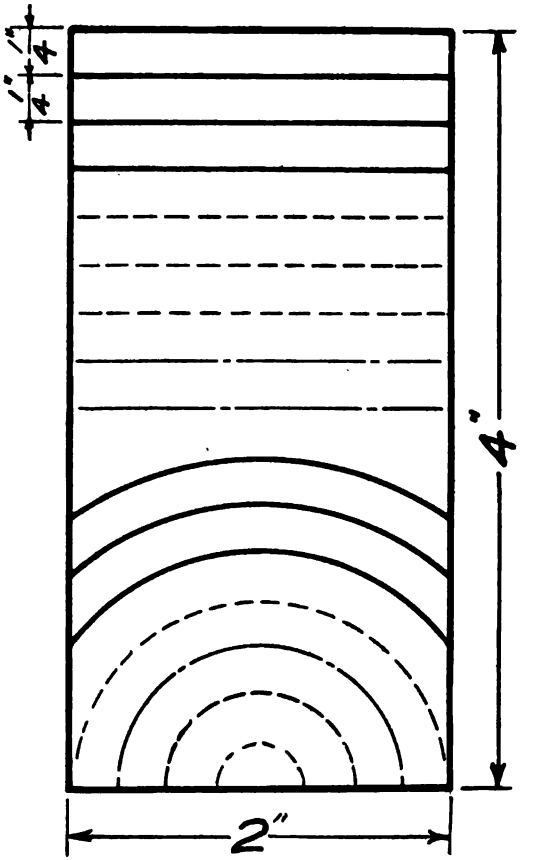


Fig. 24.

3. Don't quit work without cleaning your instruments and putting them carefully away.

BEFORE HANDING IN YOUR DRAWING.

Be sure that:—

1. It is correct—
   The views agree with each other.
   The proper lines are used.
   The dimensions are correct.
   There are no misspelled words.
2. It is legible—
   The object stands out clearly.
   The dimensions are easily found.
   Letters and figures are easily read.
   Notes are well stated.
3. It is neat—
   The drawing is well placed.
   Letters are same slant, size and weight.
   No double lines or erasures show.
   All finger-marks and blots are removed.

Motto: MY VERY BEST. —M. V. B.

SCALE DRAWINGS.

These are drawings which are not the same size as the objects they represent.

In Plate 1 the problems are to be drawn full size but problems may be drawn to other scales, such as:

Half size, or $\frac{1}{2}''=1''$.
Three-fourths size, or $\frac{3}{4}''=1''$.
Three-eighths size, or $\frac{3}{8}''=1''$.

These scales are found on the triangular scale, and there are several others, such as:—

$\frac{1}{8}''=1'\text{-}0''$, $1''=1'\text{-}0''$ and $1\frac{1}{2}''=1'\text{-}0''$. See Fig. 25. These figures mean for example, that $\frac{1}{8}''$ on the drawing equals $1'\text{-}0''$ on the object.

Fig. 25.

Looking at Fig. 25, we see that the small divisions to the left of zero represent the subdivision of an inch or a foot and those to the right represent the entire inch or foot.

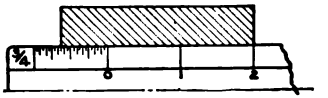


Fig. 26.

In Fig. 26 we see an object $2'\ 7\frac{1}{2}''$ long when measured by the scale of $\frac{3}{4}''=1'\text{-}0''$.

How far is it from A to B according to the

following scales: $\frac{1}{8}''=1'\text{-}0''$, ans. ( ).

Fill in the answers to show that you know how to use a scale.

$\frac{1}{2}''=1''$, ans. ( ), $1''=1'\text{-}0''$, ans. ( ), $6''=1'\text{-}0''$, ans. ( ).

STANDARD METHODS OF SHOWING DIMENSIONS.

This lesson is very important; study it carefully. The samples in the two columns show the difference between the work of a trained and untrained draftsman.

Notice (1) Dimensions should be placed about ¼" away from the object. The light line which locates the arrow head is called an extension line and is never attached to the object. (Fig. 27.) Some draftsmen use one small space as at A, while others use two as at B. Whichever method is applied be sure to adhere to it throughout your work. How many defects can

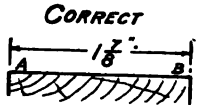


Fig. 27.

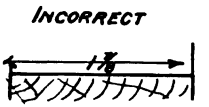


Fig. 28.

you find in Fig. 28? Practice till you can make arrow-heads shaped like the point of a sharp steel pen. (Fig. 29.)


Fig. 29.

(2) The extension lines are always perpendicular to the line to be dimensioned. (Fig. 30).

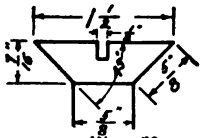


Fig. 30.

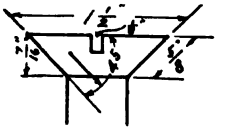


Fig. 31.

What is wrong with Fig. 31? Note how the slant of the lines is shown.

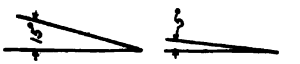


Fig. 32.

The size of small angles is shown thus. (Fig. 32).

(3) Whenever possible place the detail dimensions in a line, with the overall dimensions at the outside. (Fig. 33). Do not cross the detail dimensions as in Fig. 34. What other

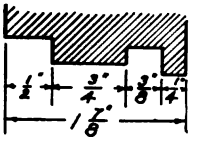


Fig. 33.

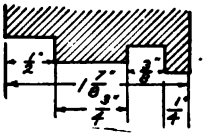


Fig. 34.

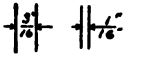


Fig. 35.

mistakes do you find in Fig. 34? Do the dimensions add up right? This is very important. Very narrow spaces are shown thus: (Fig. 35).

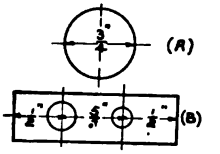


Fig. 36.

(4) Never show the diameter of a circle on a center line, neither horizontal nor vertical, as is done in Fig. 36A, but at an angle as in Fig. 37A. Dimensions between circles are shown correctly in Fig. 37B.

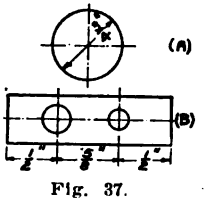


Fig. 37.

Small diameters are shown thus: (Fig. 38).

Small arcs are like this: (Fig. 39).

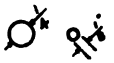


Fig. 38.

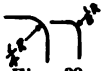


Fig. 39.

(5) Never use a center line as a dimension line. Notes concerning circles should be neatly placed. (Fig. 40). Avoid doing as in Fig. 41.

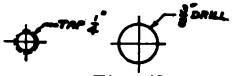


Fig. 40.

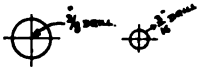


Fig. 41.

(6) In dimensioning a symmetrical object, do not place dimensions on the center line as in Fig. 42. Notice how space (a) is dimensioned in Fig. 43.

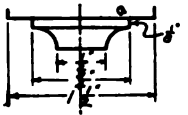


Fig. 42.

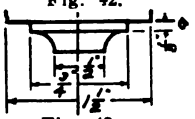


Fig. 43.

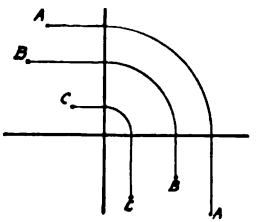
(7) Dimensions must be read from the bottom or right hand side of the drawing only. They should always be placed in line with the dimension line, never across it.

WORKING DRAWINGS.

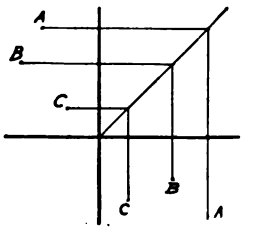
There are two ways of representing an object. First, by perspective, or as it appears to the eye. Second, by working drawings which give the exact size and shape, so that a mechanic can make the object completely from the drawings. In Plate 3, both perspective and working drawings are shown.

When necessary the material is indicated, and cross sections are made whenever the construction is difficult to understand. (See Plate 2 "A"). Interior or hidden portions are also shown by fine short dash lines. (Plate 1, Prob. 3). In working drawings, three views are usually shown, taken from points directly opposite the top, the front, and the side of the object. If the object consists of a single piece three views are sufficient, but when there are several parts that are fitted together two sets of drawings may be necessary;—(a) The detail drawing which is a working drawing of each part; (b) The assembly drawing which shows the object when all the parts are in place. See Plates 12 and 12a.

Other methods of connecting top and end view:



A.

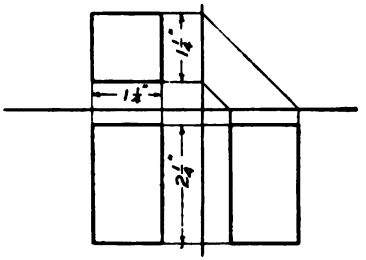


B.

Note: Cuts A and B show two other methods of connecting the top and side views different from that used in Plate 1. All three methods are correct, but the teacher should advise the pupil as to which system he prefers.

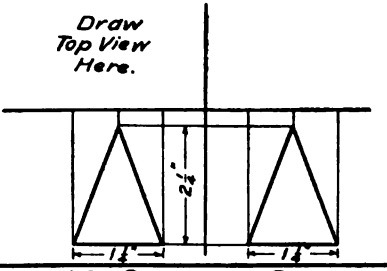
NOTE:- The instructor may, from time to time, substitute any one of these problems for any of those on Plate I. Each problem fits in a space 5" x 6½" if drawn full size.

PROB I-A SQUARE PRISM.

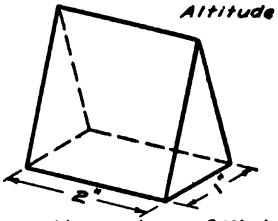


PROB. I-D SQUARE PYRAMID.

Draw Top View Here.

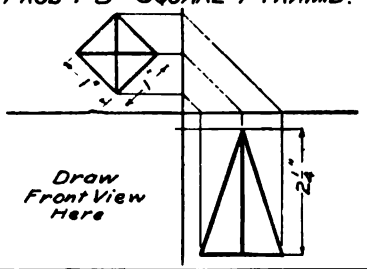


PROB. I-G WEDGE.



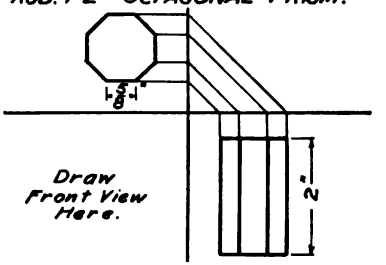
Draw three views of Wedge so placed that triangle shows in side view.

PROB I-B SQUARE PYRAMID.



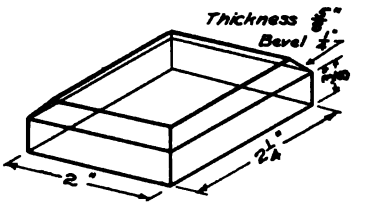
Draw Front View Here

PROB. I-E OCTAGONAL PRISM.



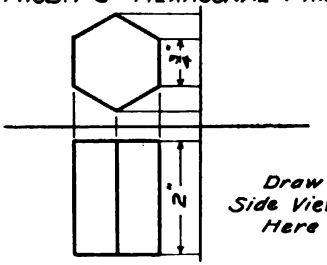
Draw Front View Here.

PROB. I-H GLASS PAPER WEIGHT.



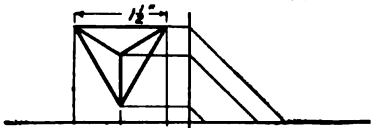
Draw three views of bevelled paper weight.

PROB. I-C HEXAGONAL PRISM.



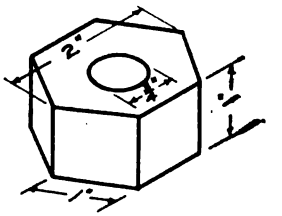
Draw Side View Here

PROB. I-F TRIANGULAR PYRAMID



Draw three views of pyramid. Altitude 1⅛". Base is an equilateral triangle.

PROB. I-J HEX. NUT BLANK.



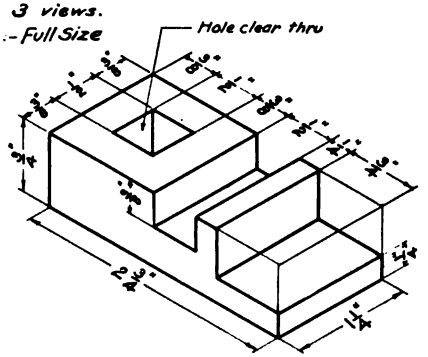
Draw three views of Blank, placed so three faces show in front view.

PLATE 2

Use one or more of these problems for Plate 2, depending upon the scale chosen.

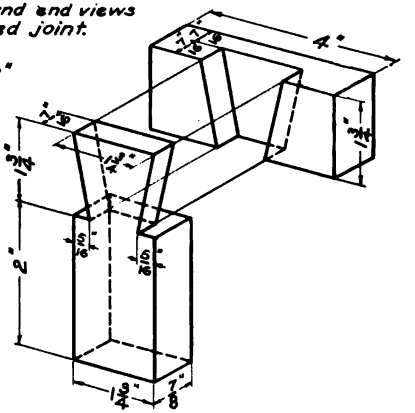
PROB. CHISELING EXERCISE.

Draw 3 views.
Scale :- Full Size



PROB. HALF LAP DOVETAIL JOINT.

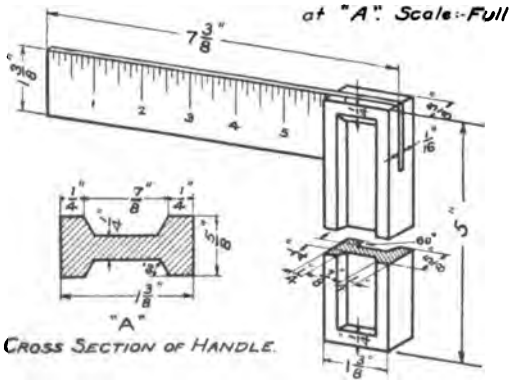
Draw front and end views of assembled joint.
Scale :- $\frac{3}{4}$" = 1"



PROB. TRY SQUARE.

Draw front and end views.
Scale :- 6" = 1'-0".

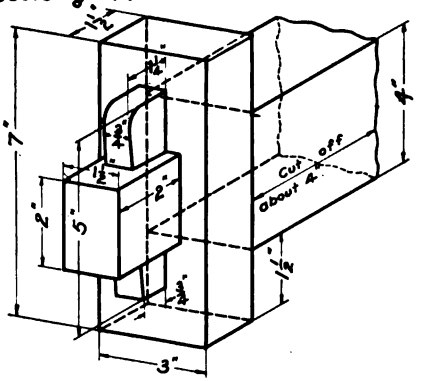
Also show cross section of handle as shown at "A". Scale :- Full Size.



CROSS SECTION OF HANDLE.

PROB. KEYED MORTISE AND TENON JOINT.

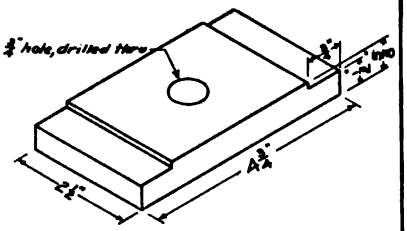
Draw 3 views of assembled joint.
Scale :- $\frac{3}{8}$" = 1".



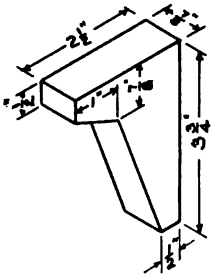
SUPPLEMENTARY PROBLEMS PLATE 2

Problems for an extra plate may be chosen from this page, using any convenient scale

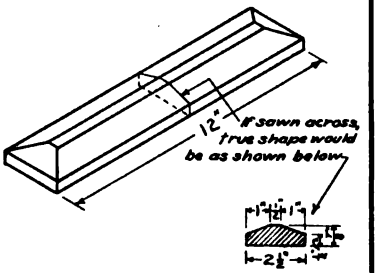
CLAMPING PLATE



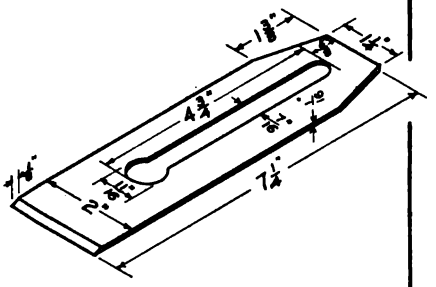
SHELF BRACE



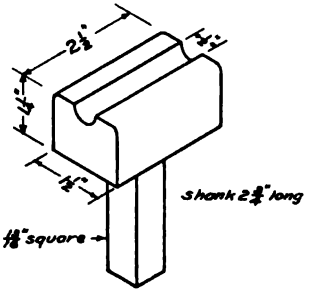
CLEAT



PLANE BLADE



BOTTOM SWAGE



CAM FINGER

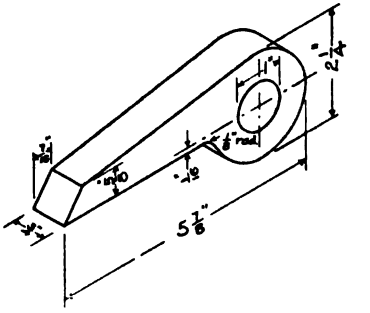
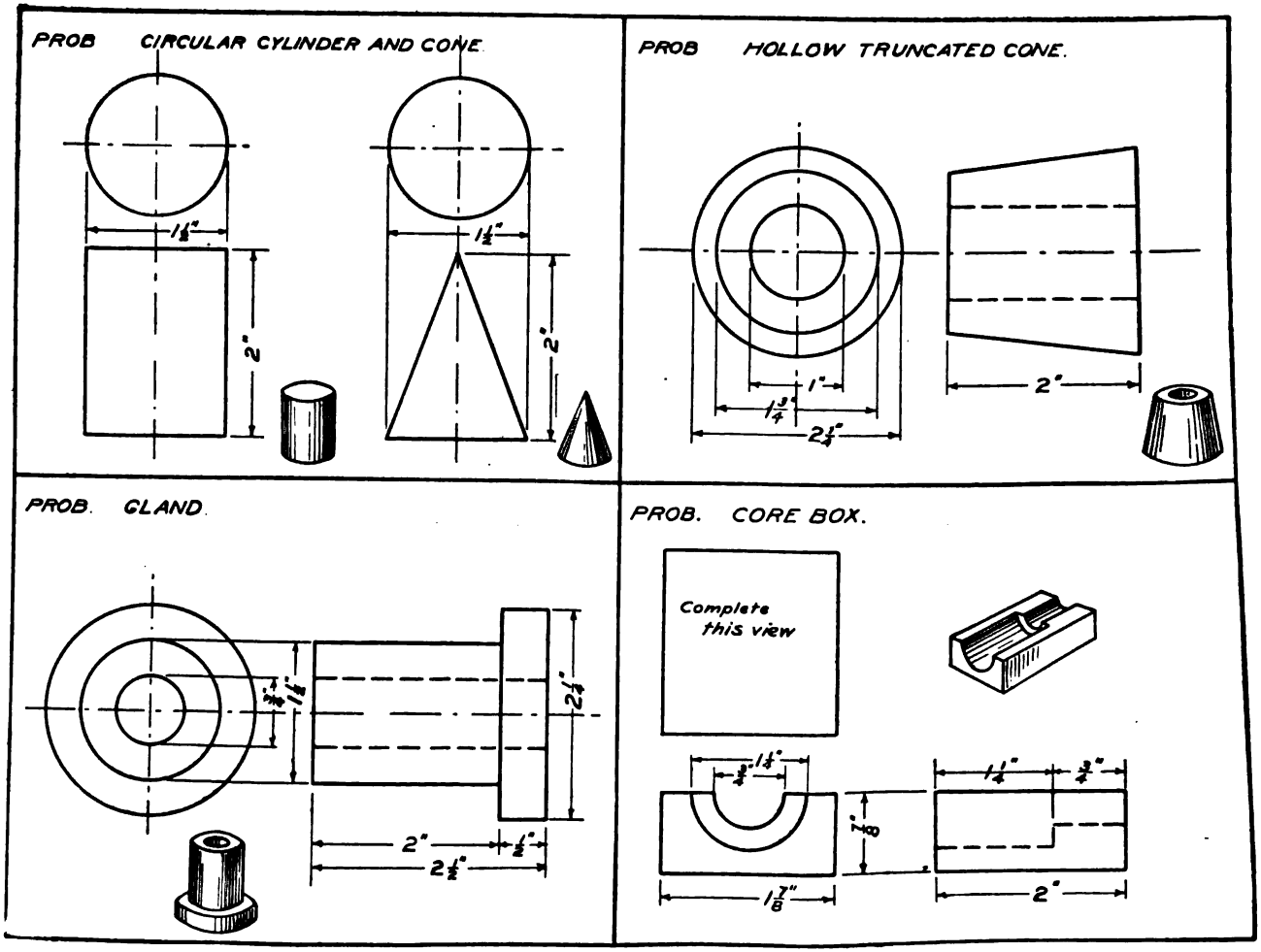


PLATE 3


PROB CIRCULAR CYLINDER AND CONE.
1½"
2"
1½"
2"
PROB HOLLOW TRUNCATED CONE.
1"
1¾"
2¼"
2"
PROB. GLAND.
2¼"
1"
2"
2¼"
PROB. CORE BOX.
Complete this view
1½"
⅜"
1⅛"
1¼"
¾"
1⅞"
2"

PROBLEMS USING CIRCLES.

In drawing a circle the first thing is to find the center. Therefore lay out the center lines first, using fine dot and dash lines as shown on the opposite page. When drawing cylinders and cones always draw the end or circular view first, then project across to the other views. Never reverse the process. Why?

Caution:—To secure accuracy, when a diameter is given, be sure and draw a test circle on another piece of paper and measure its diameter to see that the compass is correctly set.

TANGENTS AND FILLETS.

Since many objects are made up of flat and curved surfaces, often connected by tangents, and castings are made whenever possible with fillets or rounded corners as in Fig. 44, it is necessary to note how smooth-flowing curves are drawn. Everything depends on how carefully you locate the center of the arc or circle.

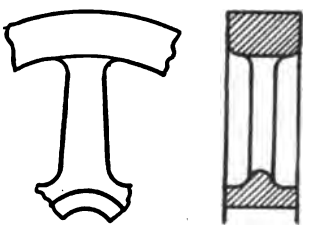


Fig. 44.

Note too in Fig. 45 that the radius which is perpendicular to the straight line shows the exact point T where the curve and the straight line meet. When a line touches a curve at a single point it is called a tangent.

Fig. 46 and Fig. 47 show curves that are tangent to each other. Note that the point of tangency T is on the line which connects the centers of the curves.

Fig. 45.

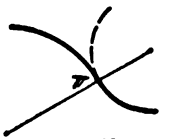


Fig. 46.

Fig. 47.

Caution:—See that the lines are in line with each other at the point of contact. Badly joined lines are very noticeable. (Fig. 48.) Do you see the reason why?

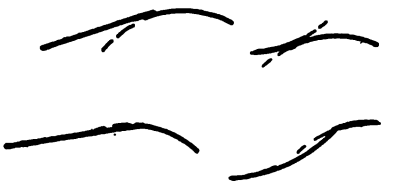


Fig. 48.

Notice on Plate 5 that the beginning and ending of each curve is shown by an arrow-head and that these arrow-heads all touch straight lines that are either perpendicular to the tangent lines or else pass through the centers of the tangent curves. See Figs. 45, 46 and 47. If these centers are carefully located and the straight lines drawn through them as shown the proper arcs can easily be filled in.

TANGENTS AND FILLETS—DATA SHEET

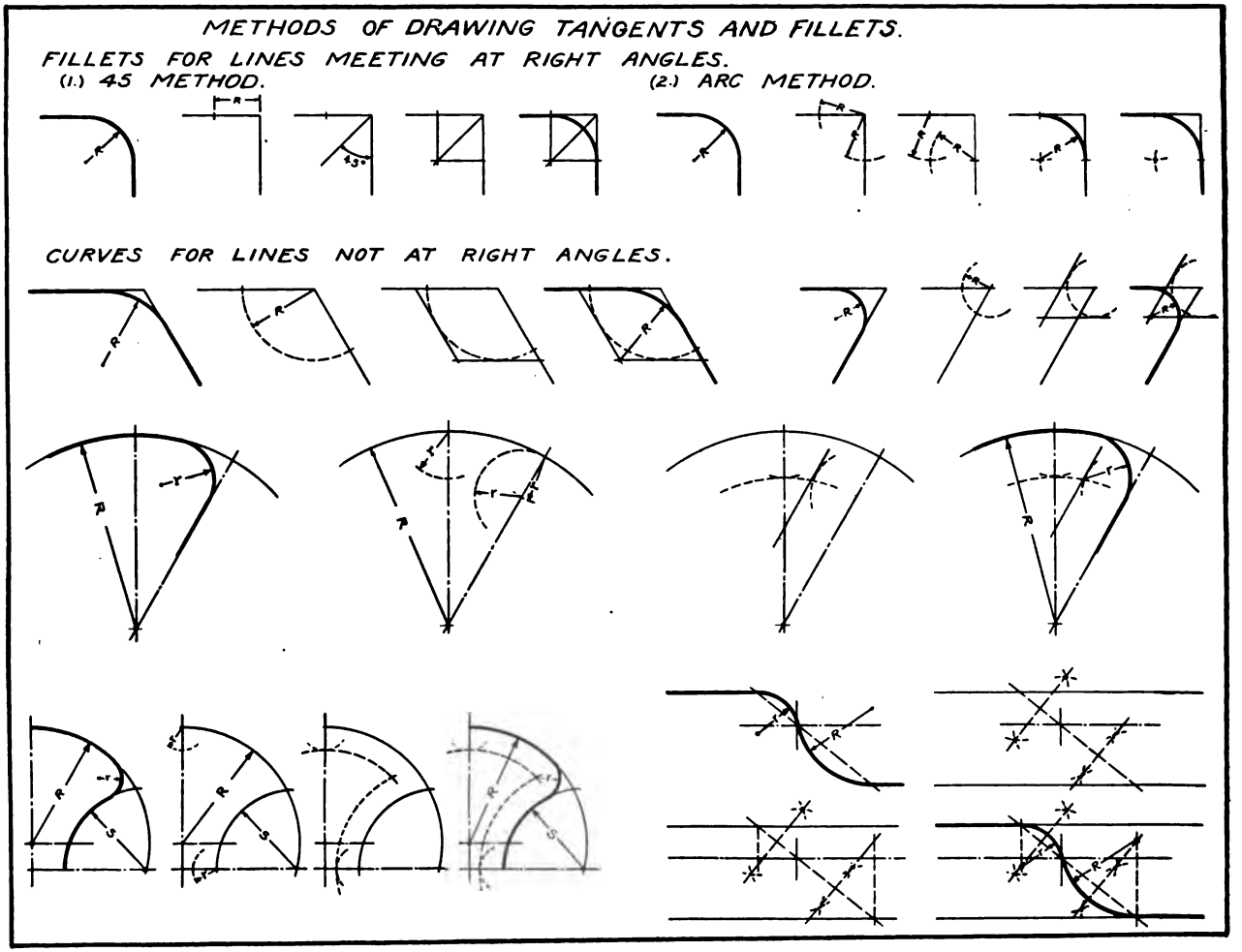
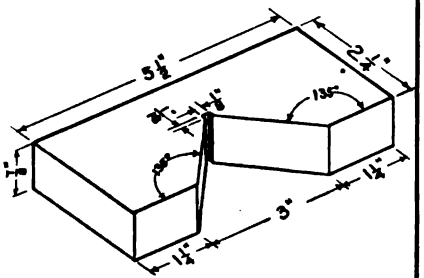


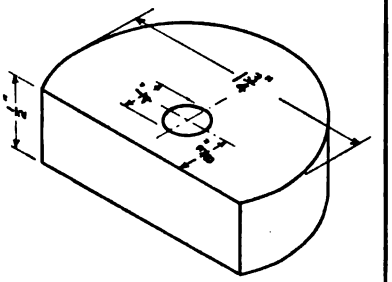
PLATE 4

Use one or more of these problems for Plate 4, depending upon the scale chosen

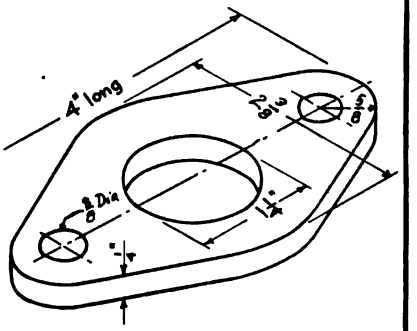
V BLOCK



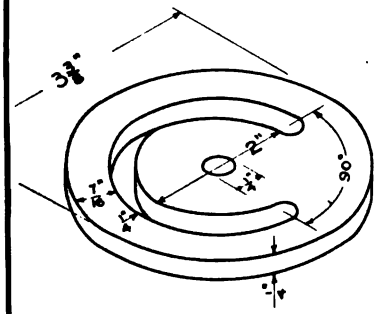
PUMP VALVE WEIGHT



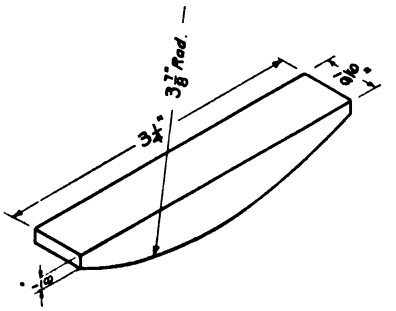
SPACER



LEATHER PUMP VALVE



TOOL POST WEDGE



STANDARD

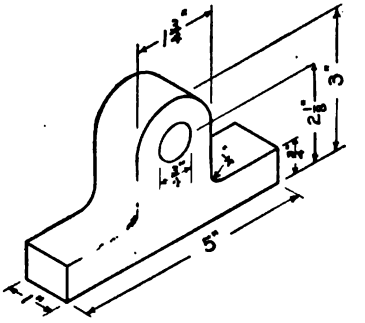
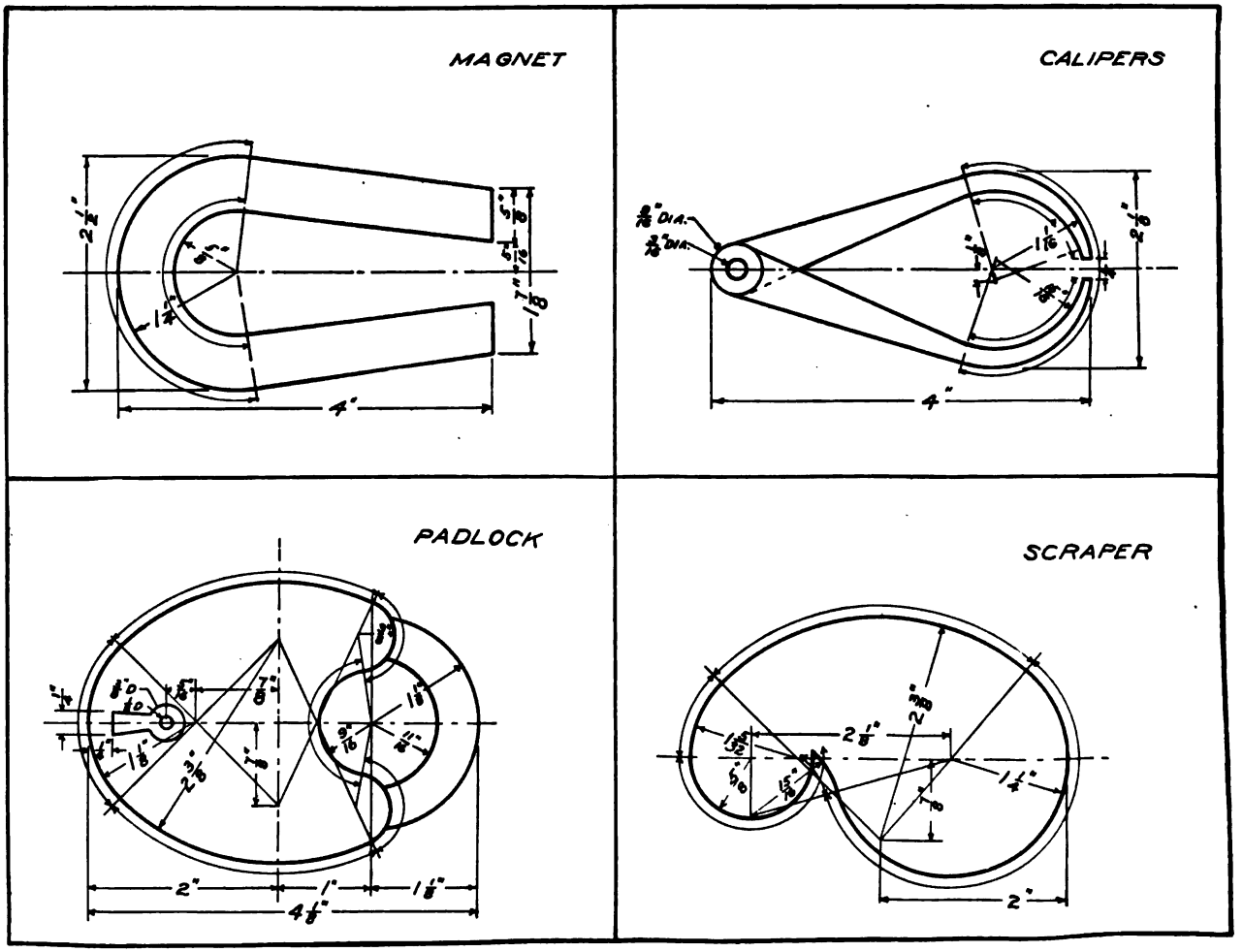


PLATE 5

This plate is for practice in drawing and joining compass curves and only one view of each object is required.



SUPPLEMENTARY PROBLEMS—PLATE 5A.

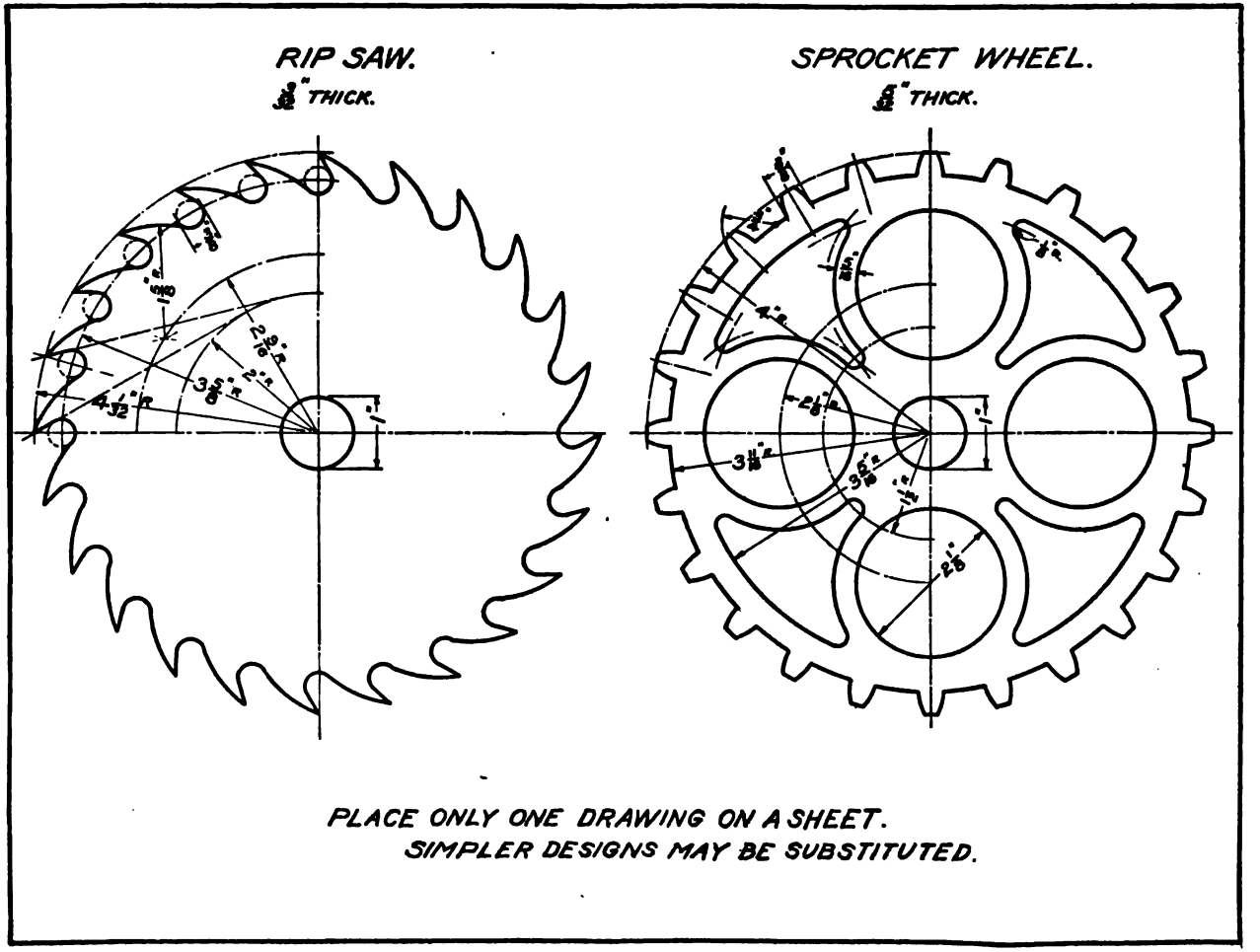


PLATE 6

Make working drawings of each of the objects.

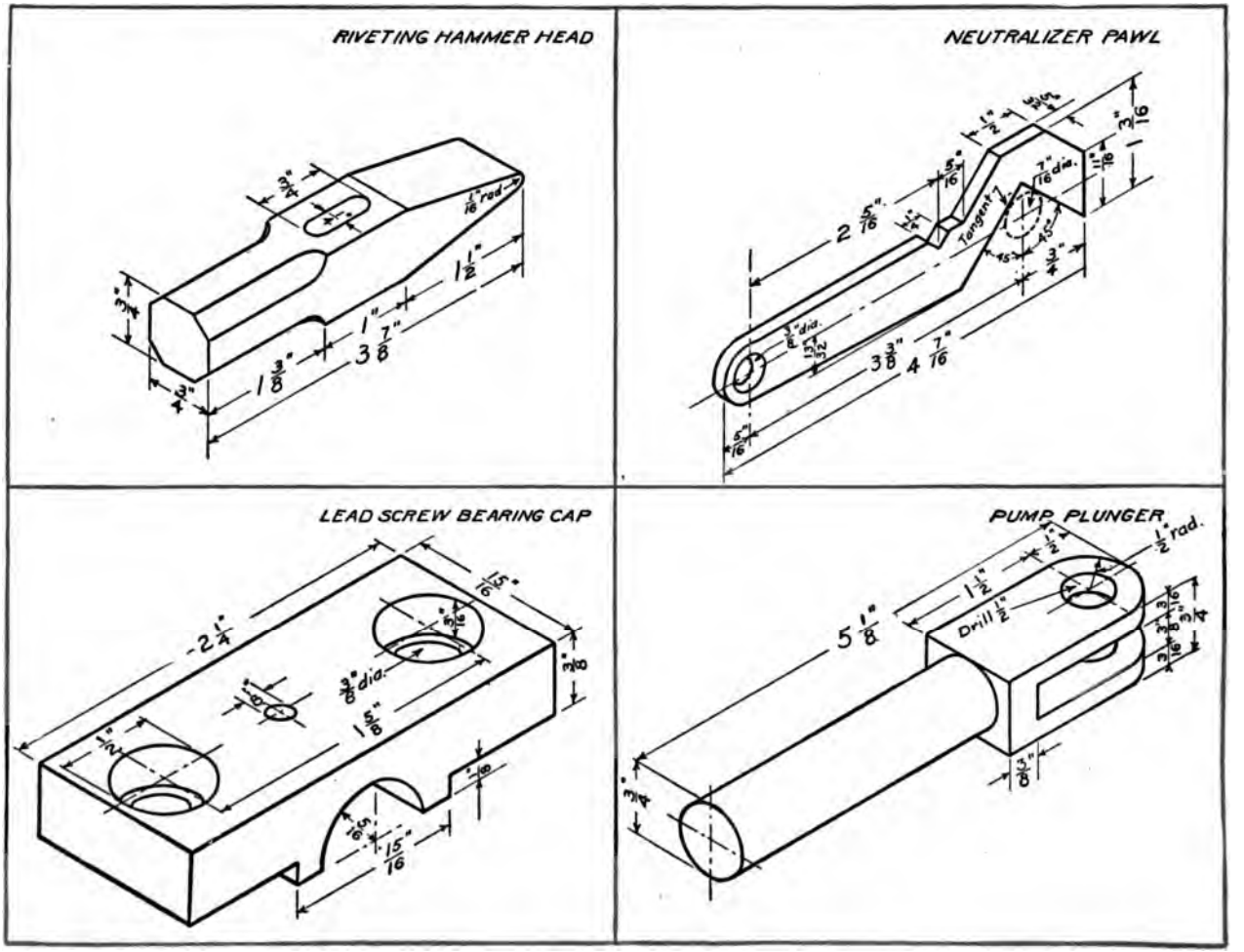
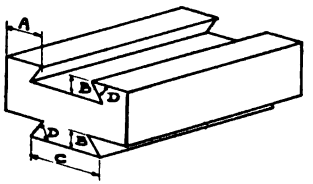


PLATE 7

PROB. DOVETAIL SLIDE

SCALE :- FULL SIZE

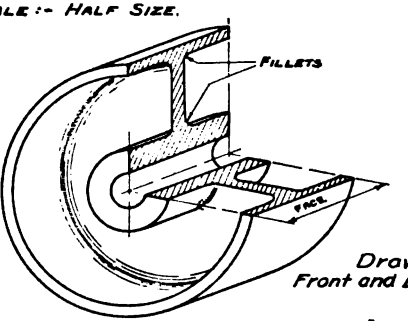


Draw three views from following description:-

Length = $2\frac{1}{2}$"	A = $\frac{1}{2}$"	C = 1"
Width = $1\frac{3}{4}$"	B = $\frac{1}{4}$"	D = 60°
Thickness = 1"		

PROB. LOOSE PULLEY.

SCALE :- HALF SIZE.

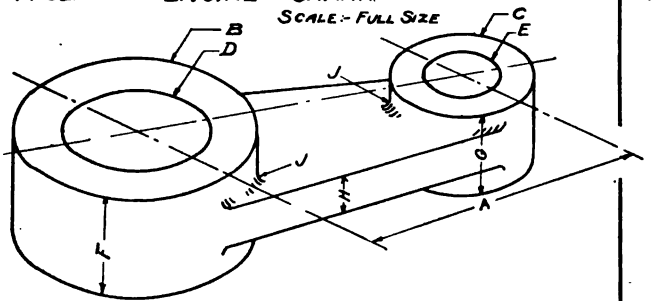


Draw Front and End Views.

Outside diameter = 7"		Length of hub = 3"		Face width 3"	
Hub " = $2\frac{1}{4}$"		Thickness of rim = $\frac{1}{4}$"		All fillets	
Hole " = $\frac{7}{8}$"		" of web = $\frac{3}{8}$"		are $\frac{1}{4}$" radius.	

PROB ENGINE CRANK.

SCALE :- FULL SIZE

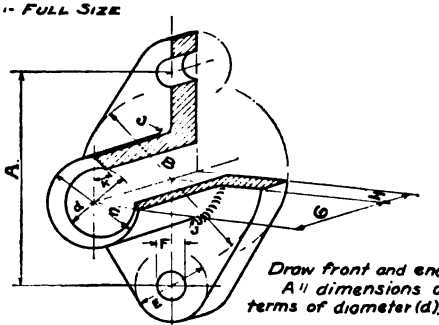


Draw front and top views from following data:-

A = $3\frac{3}{8}$"	D = $1\frac{1}{4}$" Dia	F = 1"	H = $\frac{3}{8}$"
B = 2" Dia.	E = $\frac{3}{4}$" Dia.	G = $\frac{7}{8}$"	J = $\frac{1}{8}$" Rod.
C = $1\frac{1}{4}$" Dia			

PROB. STUFFING BOX GLAND.

SCALE :- FULL SIZE



Draw front and end views. All dimensions are in terms of diameter (d), which = $\frac{3}{4}$".

A = 4 d	E = $1\frac{1}{3}$ d	H = $\frac{1}{2}$ d
B = $3\frac{1}{3}$ d	F = $\frac{1}{2}$ d	J = $\frac{1}{8}$ d
C = $1\frac{2}{3}$ d	G = $1\frac{1}{2}$ d	K = 45°

DESCRIPTIVE PROBLEMS—PLATE 8

PROBLEM.

Make working drawing of a spool, front and end views. Scale: Full Size.

Total Length=3".

Dia. of Ends=2".

Dia. Middle Section=1".

Dia. Hole thru Spool=⅝".

Ends ⅛" thick at outer edge, beveled at 45 degrees toward the middle section.

PROBLEM.

Make a working drawing of a draftsman's "T" Square.

Blade is 20" long (under head), 2" wide and ⅛" thick.

Head is 8" long, 2" wide, ⅝" thick.

Show method of fastening the head to blade.

Scale: ¼"=1".

PROBLEM.

Draw three views of oilstone case, 6" long, 2" wide, 1" high. Include the cover, which is ½" high. All material is ⅛" thick.

Scale: Half Size.

Lower Part:

1—Bottom Piece	5¾"	x 1¾
2—Sides	6"	x 1"
2—Ends	1¾"	x 1"

Cover:

1—Top Piece	6"	x 2"
2—Sides	6"	x ⅜"
2—Ends	1¾"	x ⅜"

PROBLEM.

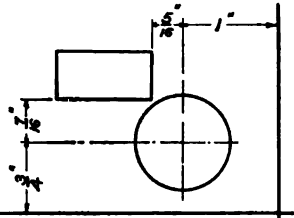
Draw three views of a cylinder 1½" dia. and 2" altitude, having a hexagonal hole cored lengthways centrally through it. Hexagon ½" on a side.

Scale: Full Size.

Hexagon is so placed that three faces are visible in the front view, two equally, one each side of the third, the middle face.

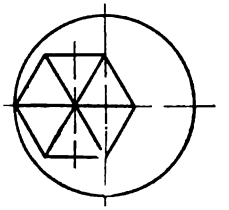
COMBINATIONS OF SOLIDS—PLATE 9

PROB. RECTANGULAR PRISM AND CYLINDER.

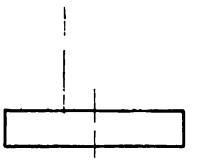


Draw three views of group consisting of Rectangular Prism $\frac{1}{2}$" × 1" × $1\frac{3}{4}$" and Cylinder 1" dia. and 2" altitude.

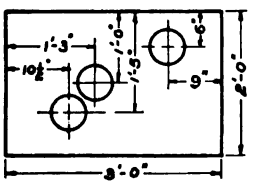
PROB. HEX. PYRAMID AND CYLINDRICAL PLINTH.



Draw three views of Hex. Pyramid $\frac{5}{8}$" edge of base; $1\frac{1}{2}$" altitude, and Cylindrical Plinth $1\frac{7}{8}$" dia. and $\frac{3}{8}$" altitude.

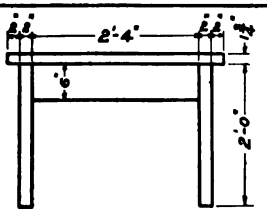


PROB. TABLE WITH SPHERES. SCALE :- $\frac{3}{4}$" = 1'-0"



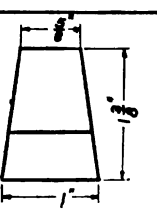
Draw three views of table with three 6" dia. spheres placed as shown.

EXTRA :- Place spheres so that they will be equally distant in front & side views.



PROB. IRREGULAR SHAPED CASTING

Draw top view here



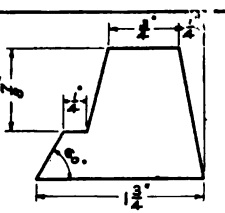
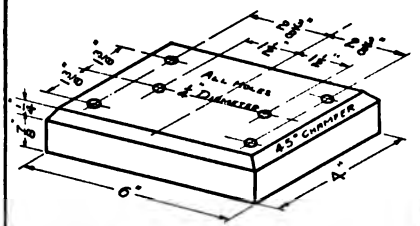


PLATE 10

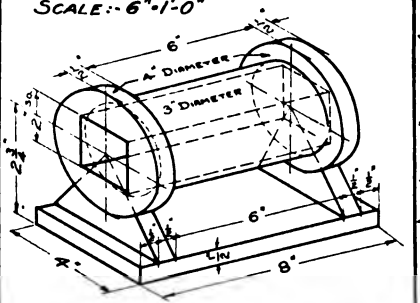
Select any of these Shop Problems for Plate 10, using a convenient scale.

PROB. SWITCH BASE.
SCALE:- 6" = 1'-0"



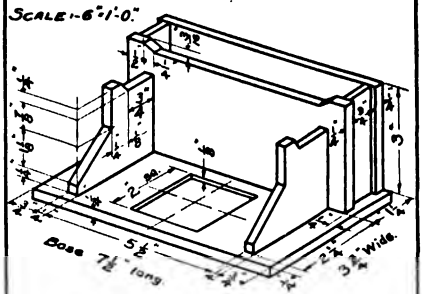
Draw three views.

PROB. REACTANCE COIL SPOOL.
SCALE:- 6" = 1'-0"



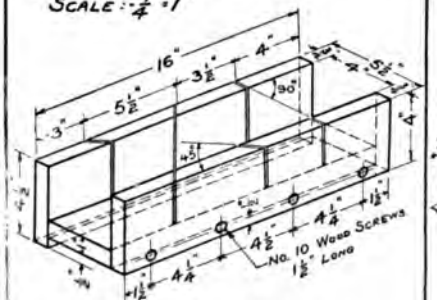
Draw front and end views.

PROB. INK STAND AND ENVELOPE CASE.
SCALE:- 6" = 1'-0"



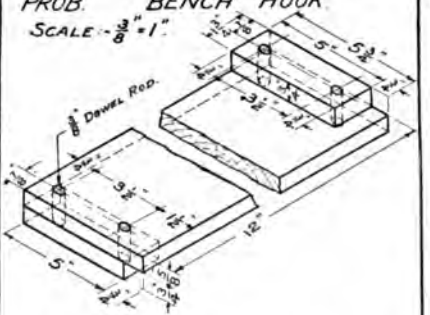
Draw three views.

PROB. MITER BOX.
SCALE:- ¼" = 1"



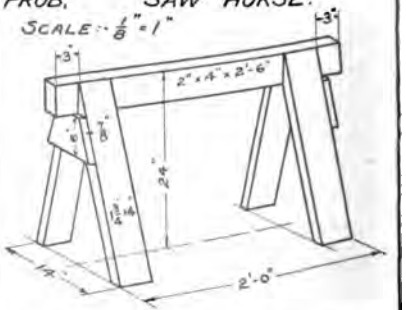
Draw three views.

PROB. BENCH HOOK.
SCALE:- ⅜" = 1"



Draw front and top views.

PROB. SAW HORSE.
SCALE:- ⅛" = 1"



Draw front and end views.

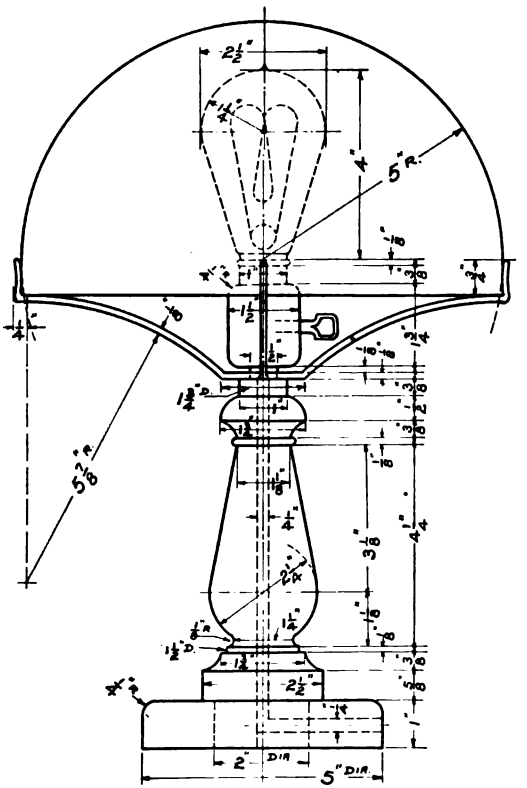
SYMMETRICAL OBJECTS – PLATE 11

PROB. ELECTRIC LAMP STAND.

SCALE :- $\frac{3}{4}$" = 1".

Draw lengthways of sheet.

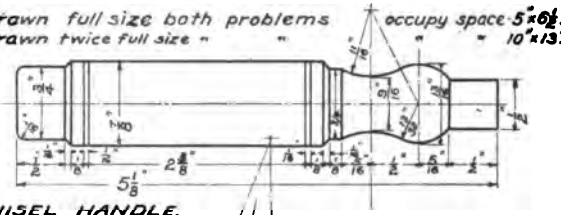
Occupies space - 10" x 13".



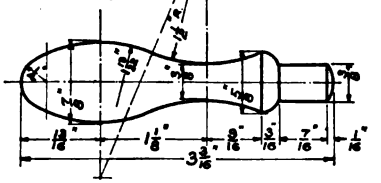
PROB. TURNING PROBLEMS.

Drawn full size both problems occupy space 5" x 6½".

Drawn twice full size " " " " 10" x 13".



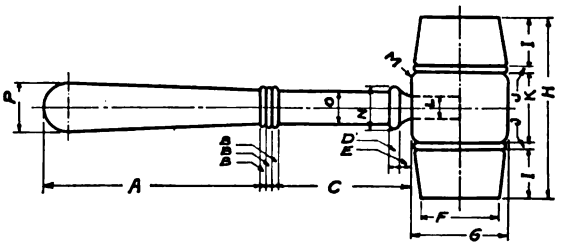
CHISEL HANDLE.



LATHE WHEEL HANDLE.

PROB. MALLET.

Drawing Occupies space 10" x 13".



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
4½"	1"	2¾"	3/16"	¼"	1⅝"	2"	3¾"	⅞"	¼"	1½"	9/16"	3/16"	⅞"	11/16"	1"

SHOP PROBLEMS—PLATE 12

The instructor may substitute any other simple construction for the towel rack if so desired.

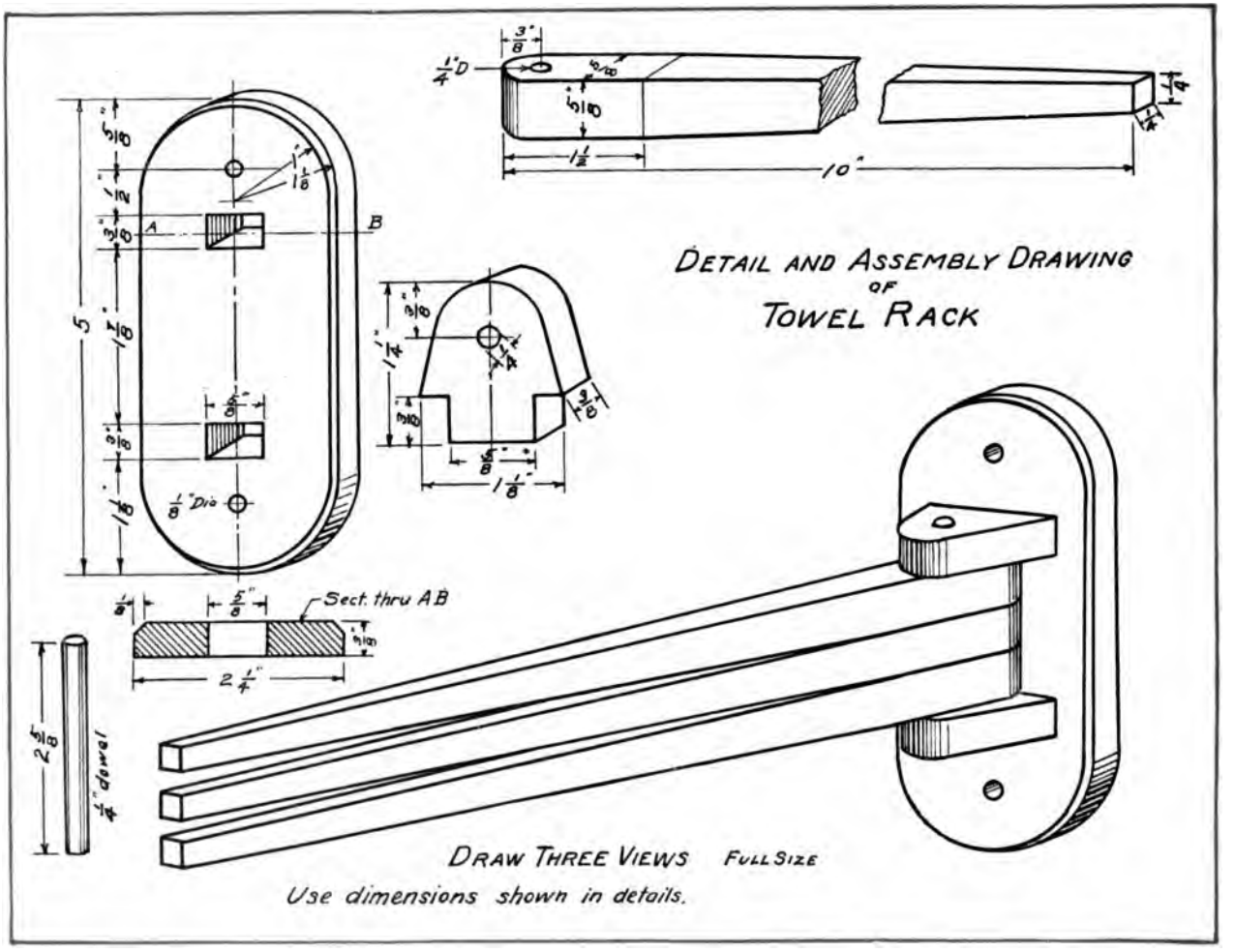
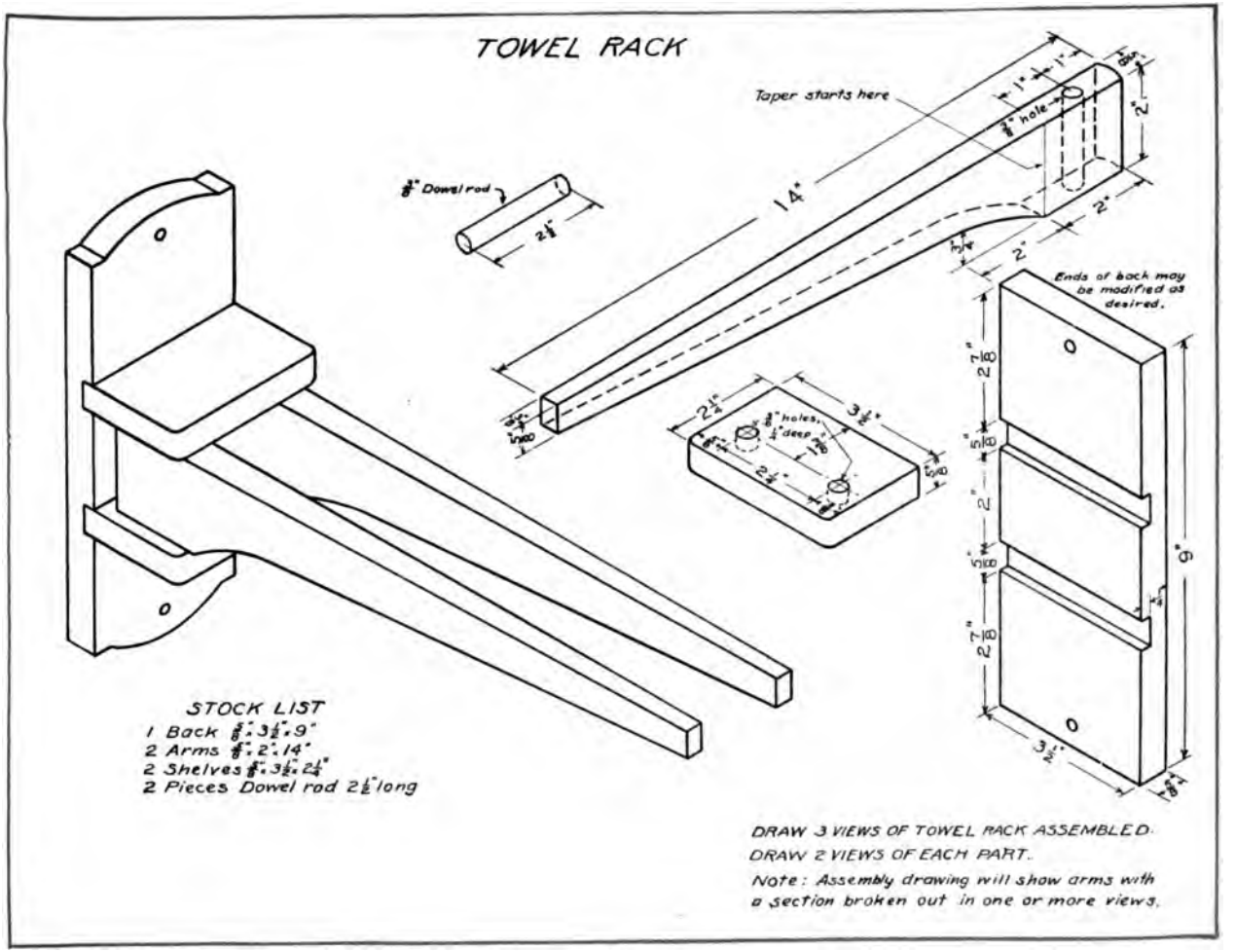


PLATE 12A


TOWEL RACK
Taper starts here
⅜" hole
⅜" Dowel rod
2½"
14"
2"
Ends of back may be modified as desired.
2 holes ¼" deep
3½"
2¼"
6"
STOCK LIST
1 Back ⅝" · 3½" · 9"
2 Arms ⅝" · 2" · 14"
2 Shelves ⅝" · 3½" · 2¼"
2 Pieces Dowel rod 2½" long
DRAW 3 VIEWS OF TOWEL RACK ASSEMBLED.
DRAW 2 VIEWS OF EACH PART.
Note: Assembly drawing will show arms with a section broken out in one or more views.

SOME GEOMETRIC PROBLEMS OFTEN USED IN MECHANICAL DRAWING.

These problems are given here because they are the basis of Mechanical Drawing and are constantly used by mechanics and designers. They should be studied as they are often referred to in the exercises found on pages 49-50, which are practical applications of these problems.

In addition they give excellent practice to a beginner in the use of a ruler and a compass, which are the only instruments required in their construction.

Problem 1. To bisect or find the middle of a given line. (Fig. 49).

Let AB be the given line. Place the compass at A, then at B and draw the two arcs of equal radius that intersect at CD. Connect CD and the point E will be the center of AB. **Note:**—The line CD is also at right angle or perpendicular to AB, showing how a right angle may be drawn without using a triangle.

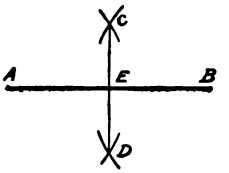


Fig. 49.

Problem 2. To bisect or find the middle of a given angle. (Fig. 50.) With a compass draw A and B equally distant from C. Then with A and B for centers draw the arc that intersects at D. Line CD will then bisect the angle ACB. **Note:**—CD also bisects the arc AB.

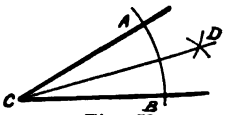


Fig. 50.

Problem 3. To trisect a right angle. (Fig. 51). With a compass lay off A and B equally distant from C. Then with A and B for centers without changing the compass lay off arc DE. Then CD and CE trisect the right angle. **Note:**—In this way angles of 30° and 60° may be obtained.

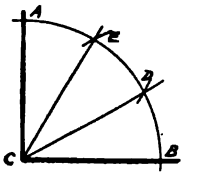


Fig. 51.

Problem 4. To divide a given line into any number of equal parts. (Fig. 52).

Let AB be the given line to be divided into five equal parts. Draw AC making an acute angle with AB. With dividers or ruler lay off on AC five equal spaces 1, 2, 3, 4, and 5. Connect five with B and then draw lines 4, 3, 2, 1, parallel to 5B. These parallels divide AB into five equal parts.

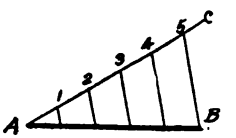


Fig. 52.

Problem 5. At a point on a given line to draw an angle equal to a given angle. (Fig. 53). Let ABC be the given angle and E be the given point on the line DE. With B as a center draw the arc 1, 2. With the same radius and E as center draw an arc cutting DE at 3. With 3 as a center and 1-2 as a radius draw the arc which cuts EF at 4. FED is then the required angle.

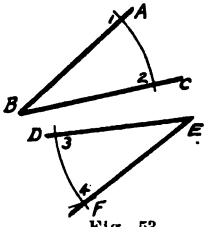


Fig. 53.

Problem 6. To draw a circle through three given points. Draw straight lines between the given points ABC. Then bisect these lines by Problem 1 and extend these bisectors until they meet at D. With D as a center and radius AD draw the required arc or circle.

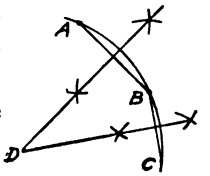


Fig. 54.

Problem 7. To find where a tangent touches a given circle. (Fig. 55). Draw a radius at right angle to the tangent either with a triangle, or geometrically as shown. Where the two straight lines intersect is the point of contact, A. **Note:**—Any line perpendicular to the outer end of a radius is a tangent.

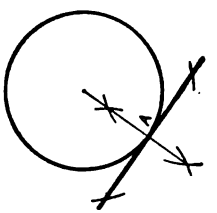


Fig. 55.

Problem 8. To draw an arc of a given radius x y tangent to both sides of a given angle, ACB (Fig. 56). Draw two lines, 1 and 2, each parallel to the given sides BC and AC of the given angle and the given distance away. Where these lines, 1 and 2 intersect at D is the center of the required circle. **Note:**—This arc, which is called a fillet, is used a great deal in machine design so that the method of drawing should be well learned.

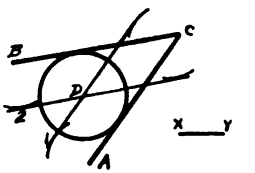


Fig. 56.

Problem 9. To divide a circle into any number of equal parts. (Fig. 57). Let the number of the required parts be seven. Using Problem 4, divide the diameter AB into as many equal parts as are required, in this case seven parts. With the radius AB and centers at A and B draw two arcs that intersect at D. From D draw straight lines through alternate points on the diameter to cut the circle at 1, 2 and 3. From these points project across the circle giving the seven equal parts required. This method is approximate.

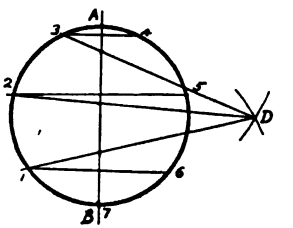


Fig. 57.

Problem 10. To surround a circle with a certain number of circles which are tangent to the

given circle and to each other. (Fig. 58). Divide the given circle into twice as many equal parts as there are circles required. See Problems 2 and 9. Draw diameters through every other division of the circle and on one of them draw a tangent as at A. If the angle formed by this tangent and the adjoining diameter B is bisected (see Problem 2) the bisector will cut the first diameter at C which is the center of one of the required circles. With O as a center and CO as a radius draw a circle cutting all the diameters which will locate the centers of all the surrounding circles.

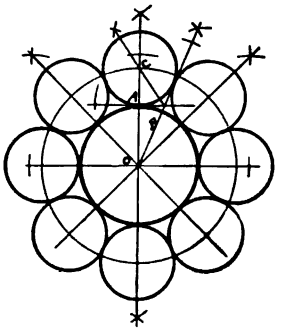


Fig. 58.

Problem 11. To draw a polygon of any number of sides having one side given. (Fig. 59). Let AB be the given side. With it as the radius draw the semi-circle OB which should be divided into as many equal parts as there are sides in the required polygon, in this case seven. If we connect point 2 with A we have the second side of the polygon, and bisecting these two sides we have the point C which is the center of the circumscribing circle in which AB will fit the required number of times.

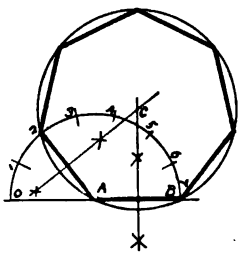


Fig. 59.

Problem 12. To draw an ellipse having two axes given. (Fig. 60). Let the axes AB and CD bisect each other at right angles. With CO as a radius draw the arc which intersects AB at E. Connect CB and lay off CF equal to EB. Bisect FB and continue the bisector till it cuts the two axes at G and H. Repeat the process to find I and J. With GB for a radius and A and I for centers, draw the two arcs MN and AS. With JD for a radius and H and J for centers draw the two arcs RN and SM. This is an approximate method.

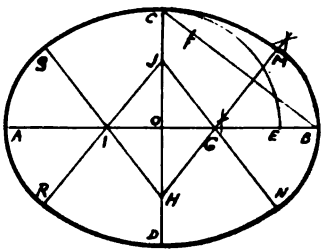
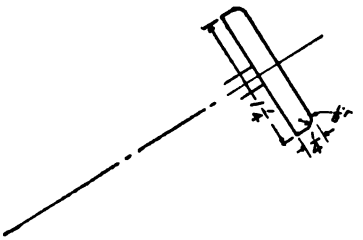


Fig. 60.

APPLICATIONS OF GEOMETRIC CONSTRUCTIONS—PLATE 13

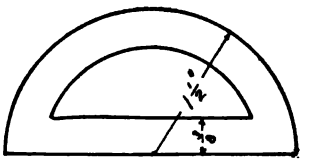
Exercise 1



TEE SQUARE

Draw a 3" blade attached to the above Tee square head. See Prob I

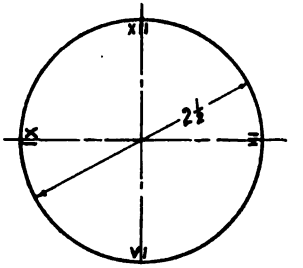
Exercise 2



PROTRACTOR

Divide the above Protractor into halves, quarters, and eighths. See Prob II Show number of degrees in each angle.

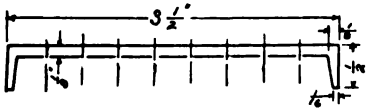
Exercise 3



CLOCK FACE

Divide this clock face into 12 equal parts See Prob. 3 Show number of degrees between 1 o'clock & 2 o'clock.

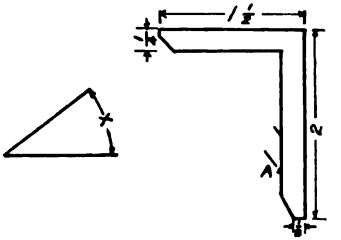
Exercise 4



RAKE HEAD

Draw Rake Head having ten teeth. See Prob. 4

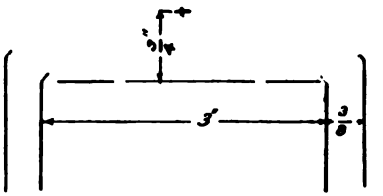
Exercise 5



BRACKET

At A add a brace to the bracket which will have the same angle as angle X. See Prob. 5

Exercise 6

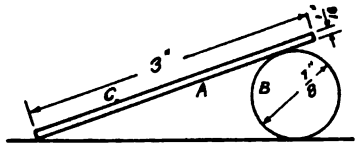


WINDOW ARCH

Draw the arch of a window which describes a curve 3" wide and $\frac{3}{4}$" high. See Prob. 6

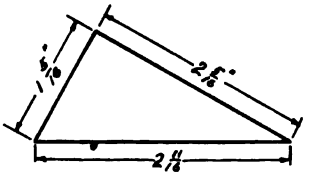
APPLICATIONS OF GEOMETRIC CONSTRUCTIONS—PLATE 14

Exercise 7



Show the exact point where the plank A rests on the ball B. Draw a ball resting on the plank at C See Prob. 7

Exercise 8



The above triangle is like one inside of a 30°-60° triangle. Draw a $\frac{1}{4}$" fillet in each corner. See Prob. 8

Exercise 9

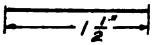
Sample

Draw a five pointed star in a $2\frac{3}{4}$ inch circle. See Prob. 9

Exercise 10

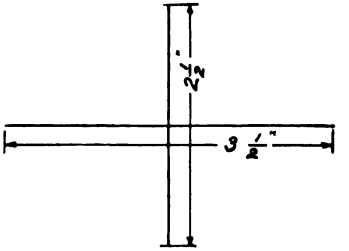
Draw the eight ball bearings that exactly fit around a one inch shaft See Prob. 10

Exercise 11



On the above line as a side draw a seven sided polygon. See Prob. 11

Exercise 12



Using the above axes draw an elliptical table mat. See Prob. 12.

SECOND SEMESTER

The aim of the first semester was to learn the use of the drawing tools; how to make good lines, letters and figures; and to obtain practice in showing the real size and shape of simple objects.

It often happens that with more complicated objects there are certain parts which we cannot understand from a simple projection drawing alone, and it becomes necessary to make additional views. Accordingly the work for this term will consist of:—

(1) Isometric drawing.
(2) Sections of simple objects.
(3) Finding true lengths.
(4) Simple problems in development.
(5) Freehand sketching.

Because the student has been using his instruments for some months it may be well to carefully inspect them before starting the second semester's work. As all drawings for this semester excepting the freehand problems should be inked, see particularly that the ruling and compass pens are clean and in condition to make clear, sharp lines. Scales, triangles and T squares may be cleaned with a damp cloth used with a little soap if necessary.

These precautions coupled with a brief review of the directions for penciling, inking, etc., should enable a student to show a marked improvement in the neatness and clearness of his drawings.

Frequent short assignments of lettering should still be given until the student's lettering is neatly, rapidly and easily done.

ISOMETRIC DRAWINGS.

If a rectangular object is drawn in perspective, its lateral edges seem to converge towards vanishing points. (Fig. 61). This makes several slanting or foreshortened lines which take time and skill to locate accurately.

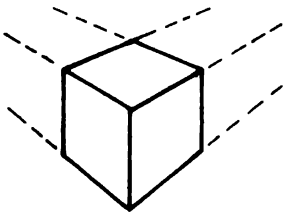


Fig. 61.

To overcome this difficulty, in isometric, all horizontal lines of the object are drawn in their full length at a uniform slant of 30 degrees. (Fig. 62). Vertical lines are not changed but are drawn vertical and full size. Thus we have a picture showing three sides at once which is more easily understood than one showing three views separately. With surfaces which are not rectangular and which consequently cannot be shown completely by 30° lines, it is necessary to put a rectangular frame around as shown in Fig. 63. Upon drawing this frame or "crate" in isometric, the distances A-B-C, etc., needed to show the hexagon in the crate, may easily be laid off and the hexagon completed.

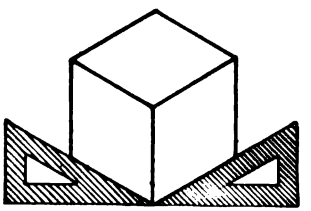


Fig. 62.

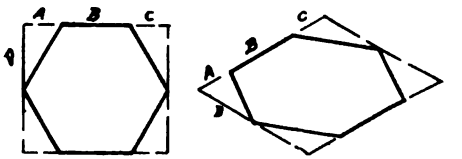


Fig. 63.

When an object has inclined edges or surfaces it cannot be drawn with the 30-degree triangle and it is necessary to draw isometric construction lines on which the given dimension can be laid off, as in Figs. 63 and 64.

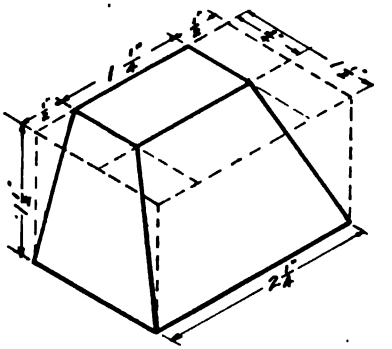
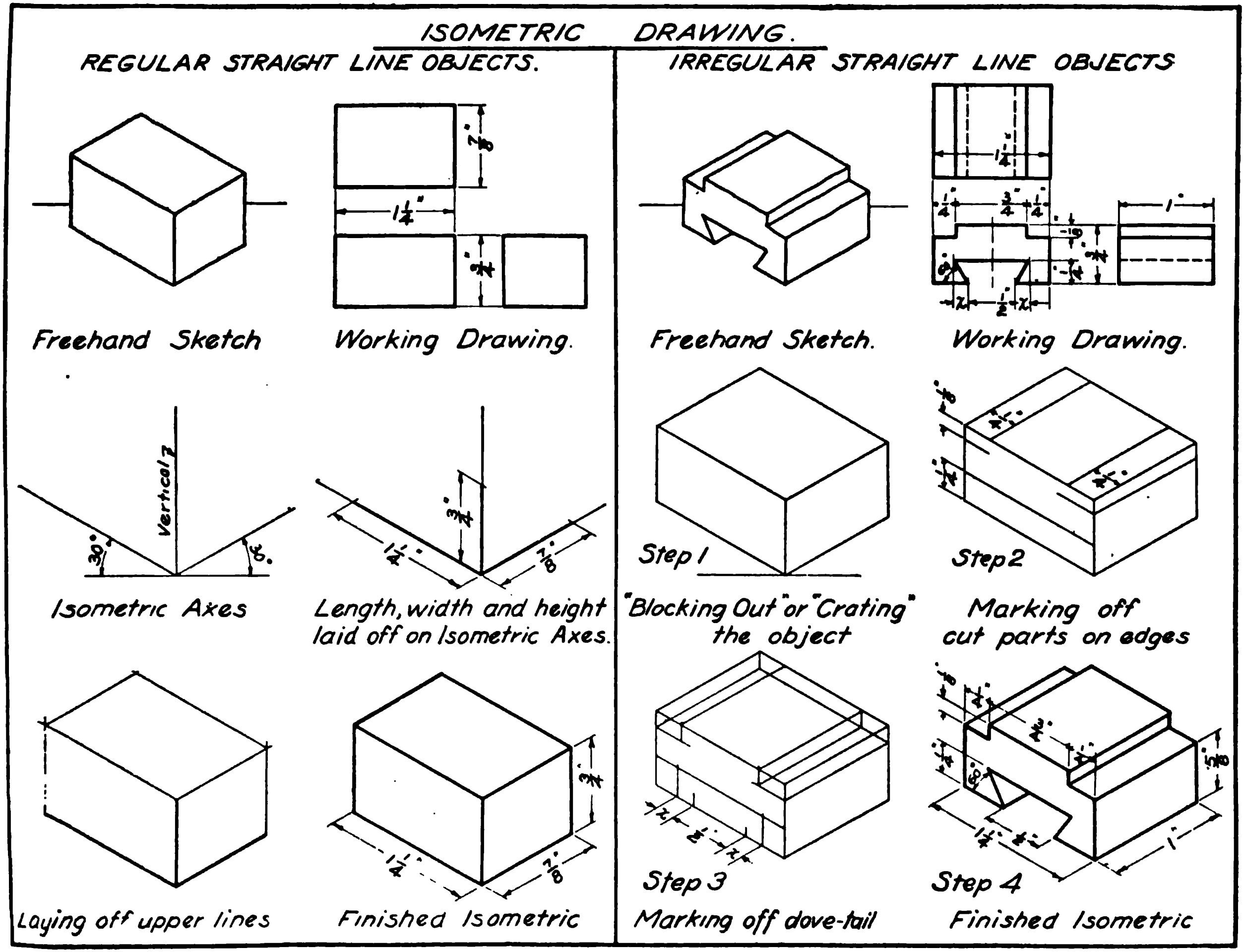


Fig. 64.

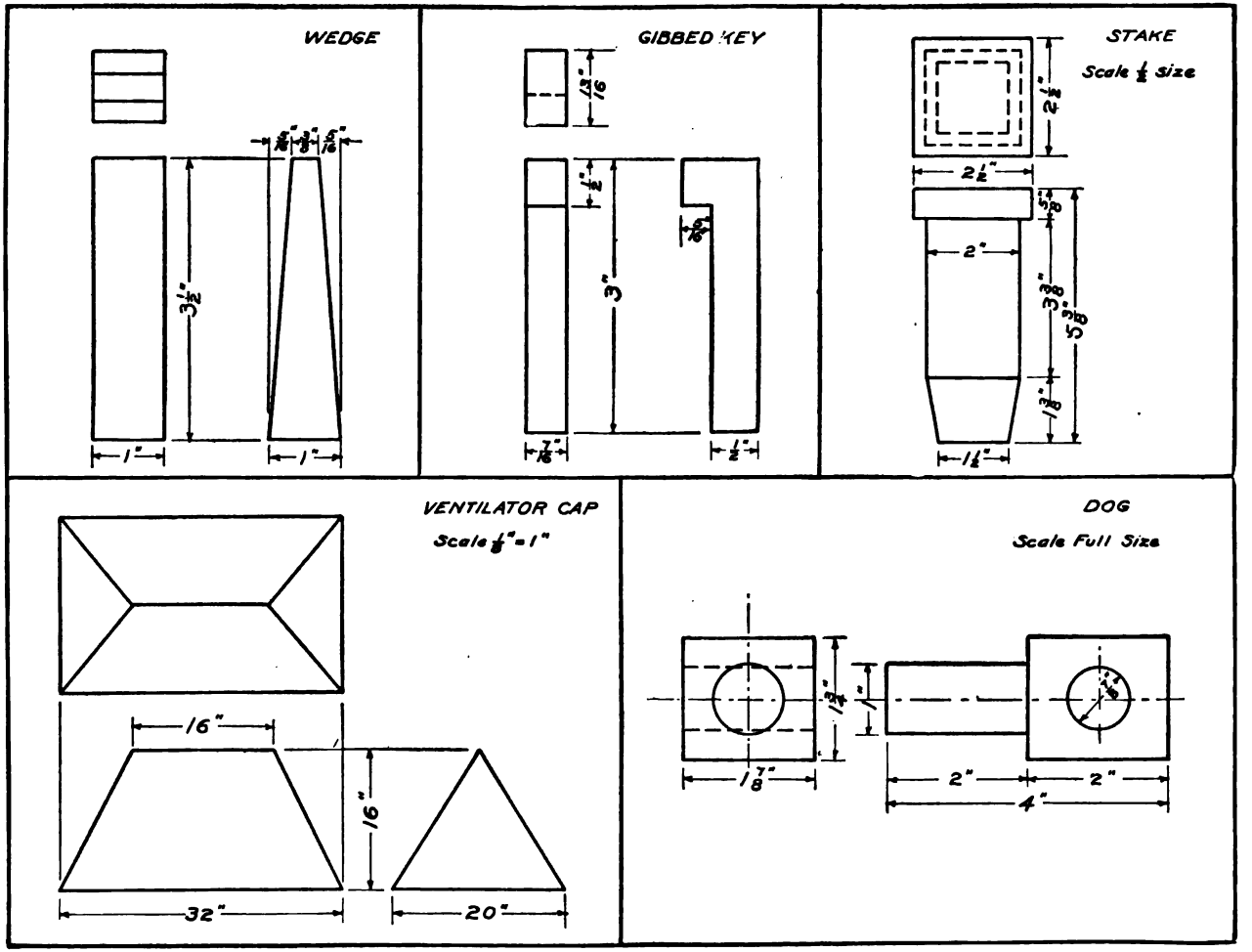
In other words always enclose the irregular object in a regular prism or "crate."

Note:—Dimensions are only laid off on vertical and 30-degree lines, which are called the isometric axes. See opposite page. Also study carefully the four steps that are used in drawing the irregular straight line object.

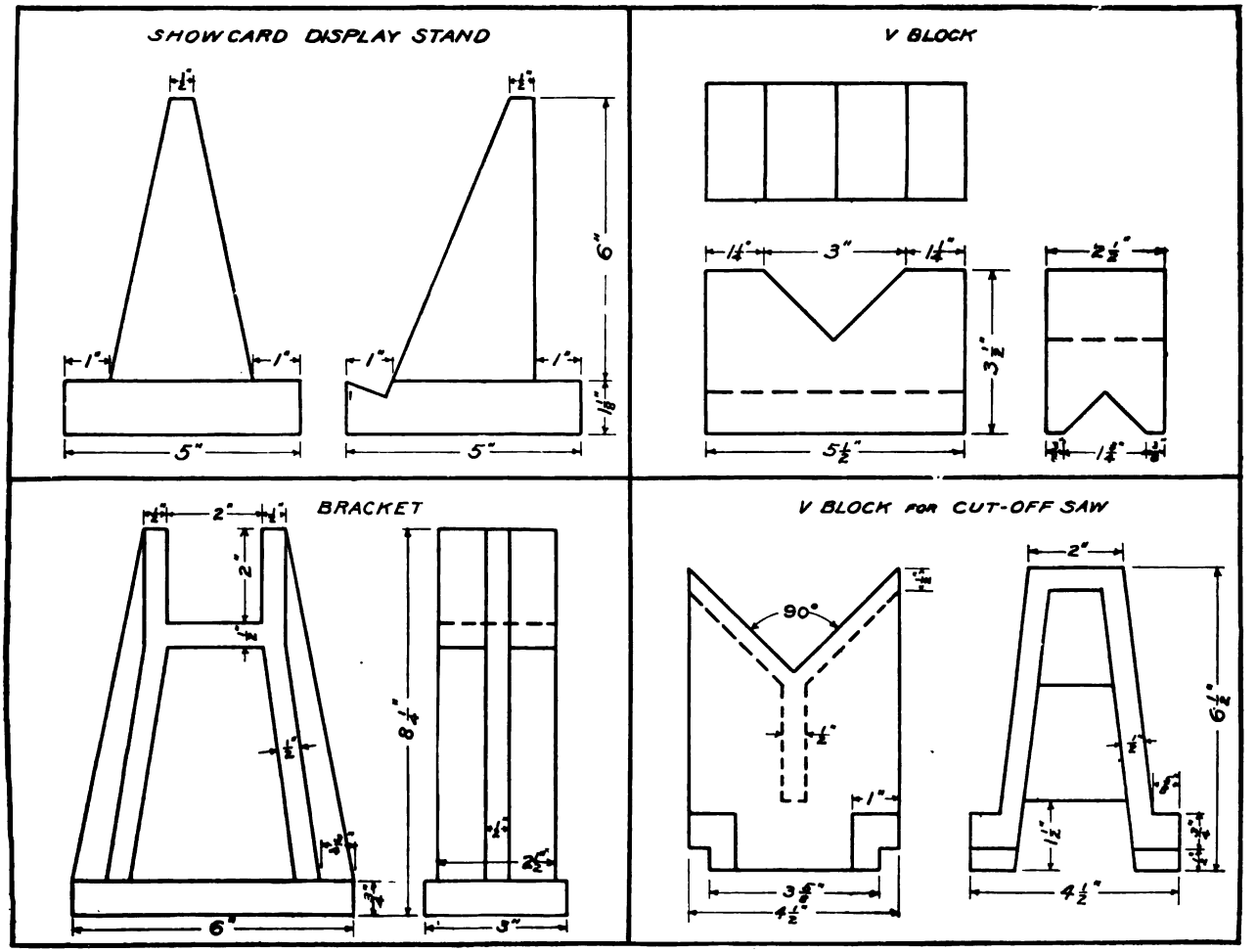
ISOMETRIC DATA SHEET



PROBLEMS FOR ISOMETRIC DRAWING—PLATE 1



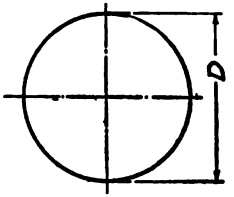
PROBLEMS FOR ISOMETRIC DRAWING—PLATE 2



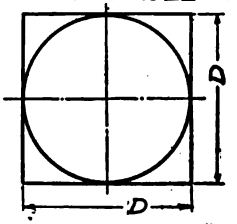
ISOMETRIC DATA SHEET

ISOMETRIC DRAWING.

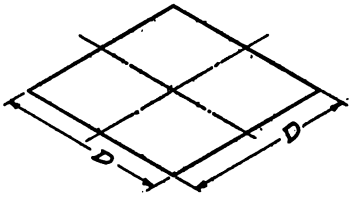
STEPS IN DRAWING A CIRCLE IN ISOMETRIC.



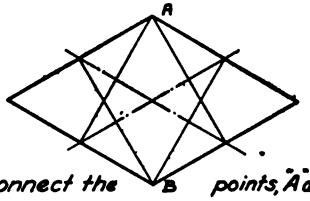
Given Circle.



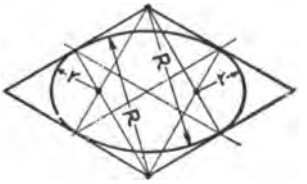
Draw square about circle.



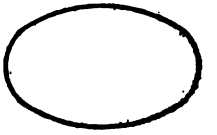
Draw square in isometric.



Connect the points "A" and "B" with middle of sides as shown.

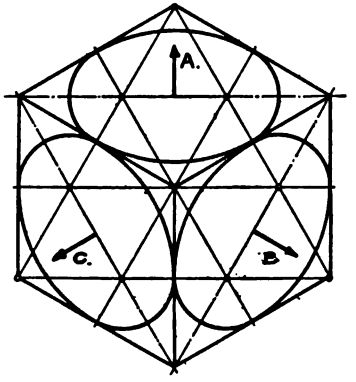


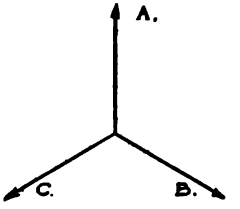
Draw curves with radii shown.



Finished Isometric Circle.

ISOMETRIC CIRCLES ON ALL AXES.



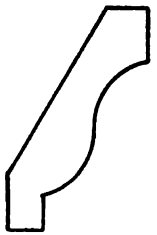


See whether your axis corresponds to "A", "B" or "C" above. Then make Isometric Circle according to "A", "B" or "C", of the Isometric Square at left.

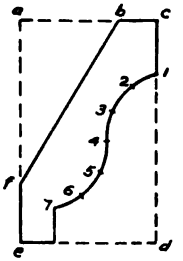
ISOMETRIC DATA SHEET

ISOMETRIC DRAWING

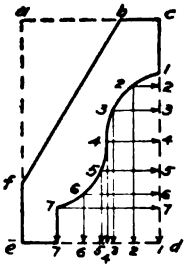
DRAWING ANY CURVED FIGURE IN ISOMETRIC.



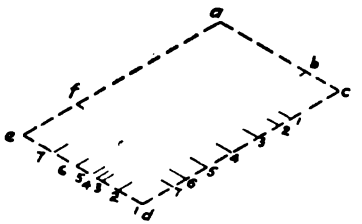
Moulding as given



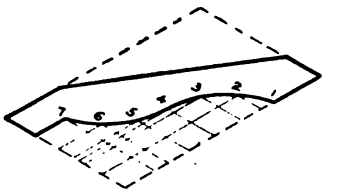
Moulding "crated in." Divide curves into any convenient number of parts, equal or unequal



Project these divisions to sides of "crate"

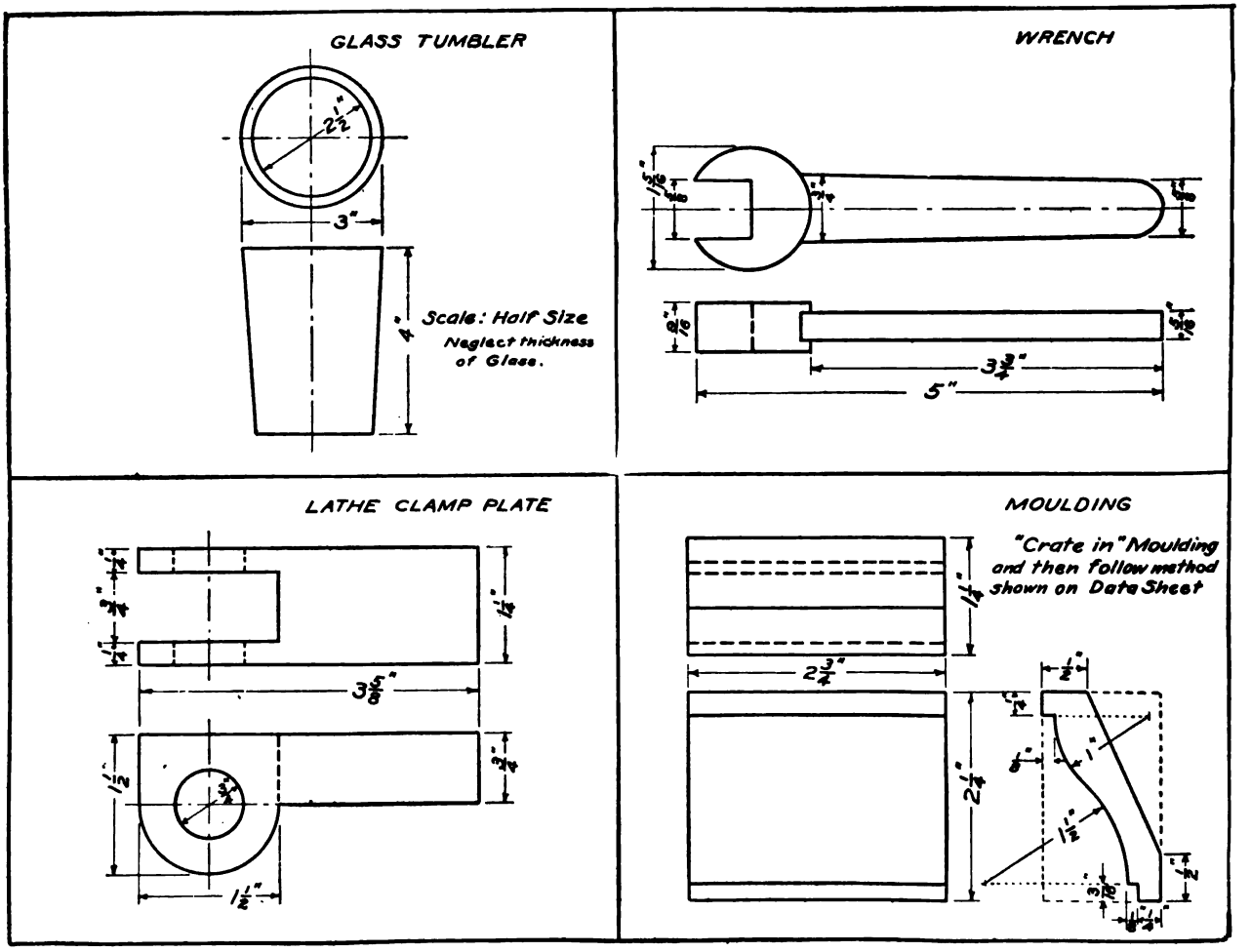


"Crate" drawn in isometric with projections marked



Finished moulding in isometric

PROBLEMS FOR ISOMETRIC DRAWING—PLATE 3



SECTIONS OF SIMPLE OBJECTS.

A Section Drawing is one which shows the real outline and interior construction of an object, as though it had been cut open along a given line.

There are two ways of making these drawings.

(1) By making a sectional view of the entire object. (Fig. 65). **Note:**—The small handle is not cross-sectioned as it is solid.

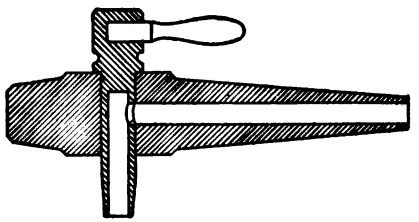


Fig. 65.

(2) By showing one or more parts on a regular view instead of making a separate drawing. (Fig. 66).

This second method is often used in the case of objects having a uniform cross section such as rails, pipes, moldings, etc.

Note:—In the working drawing of the crow bar, Fig. 66, owing to the breaks, the drawing has been shortened one-third of its real length, thus saving considerable space. The workman understands that he is not to break the bar but to make it according to the dimensions shown. The small cross sections are called revolved sections.

If an object is symmetrical, it is often sectioned in one half only. (Fig. 67). **Note:**—Be careful that the section lines are equally spaced, usually about ⅛″ or 1/16″ apart, depending on the size of the section. They should have a slant of 45 degrees, either to the right or to the left. Where parts touch each other the section lines must slant in opposite directions. What is the reason?

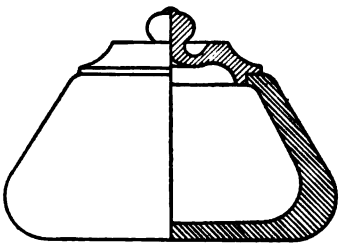


Fig. 67

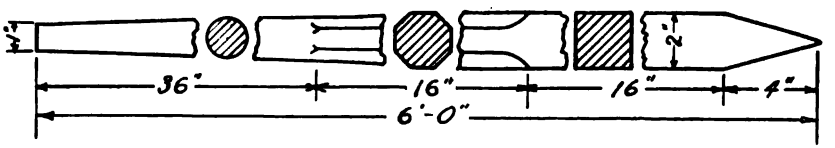
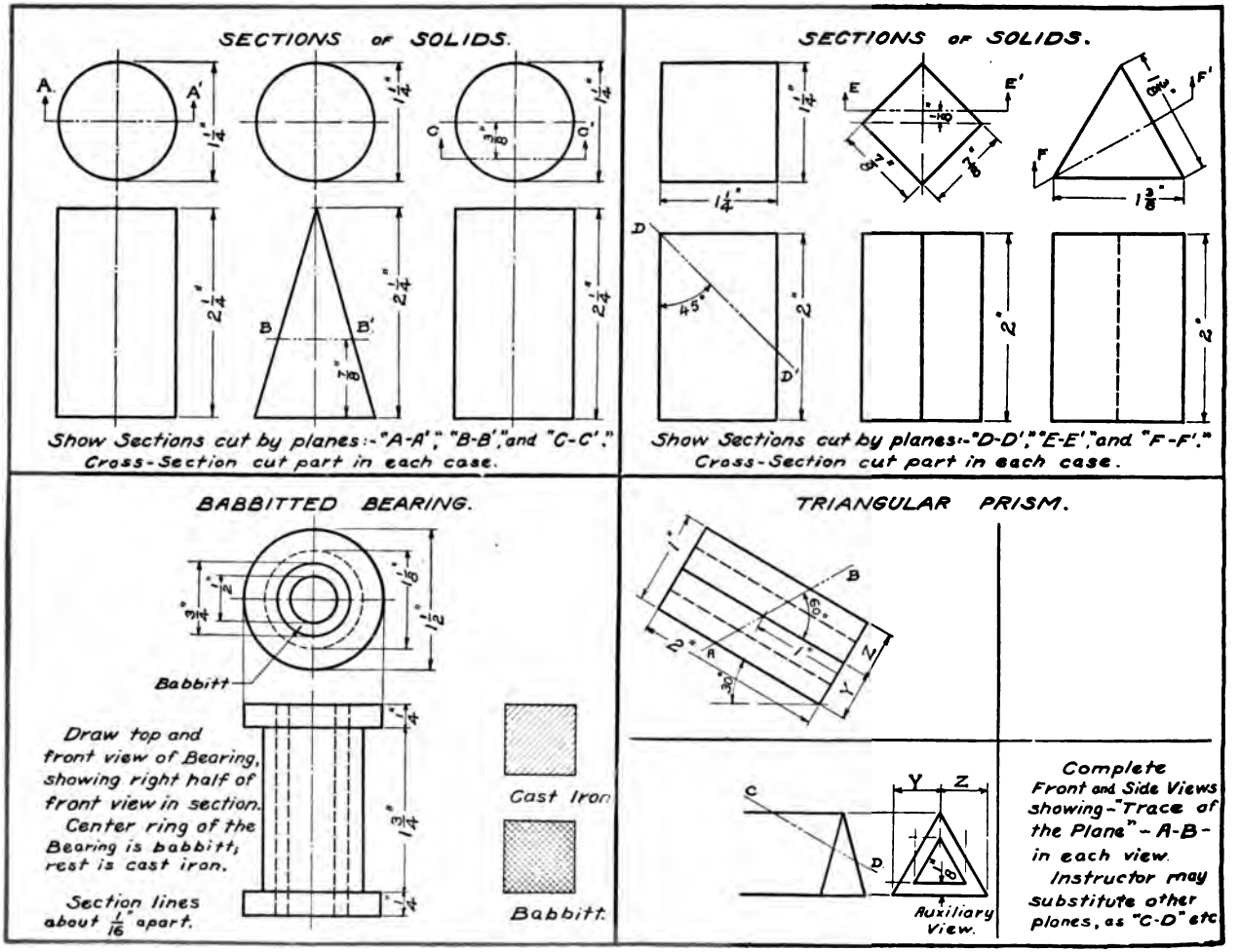
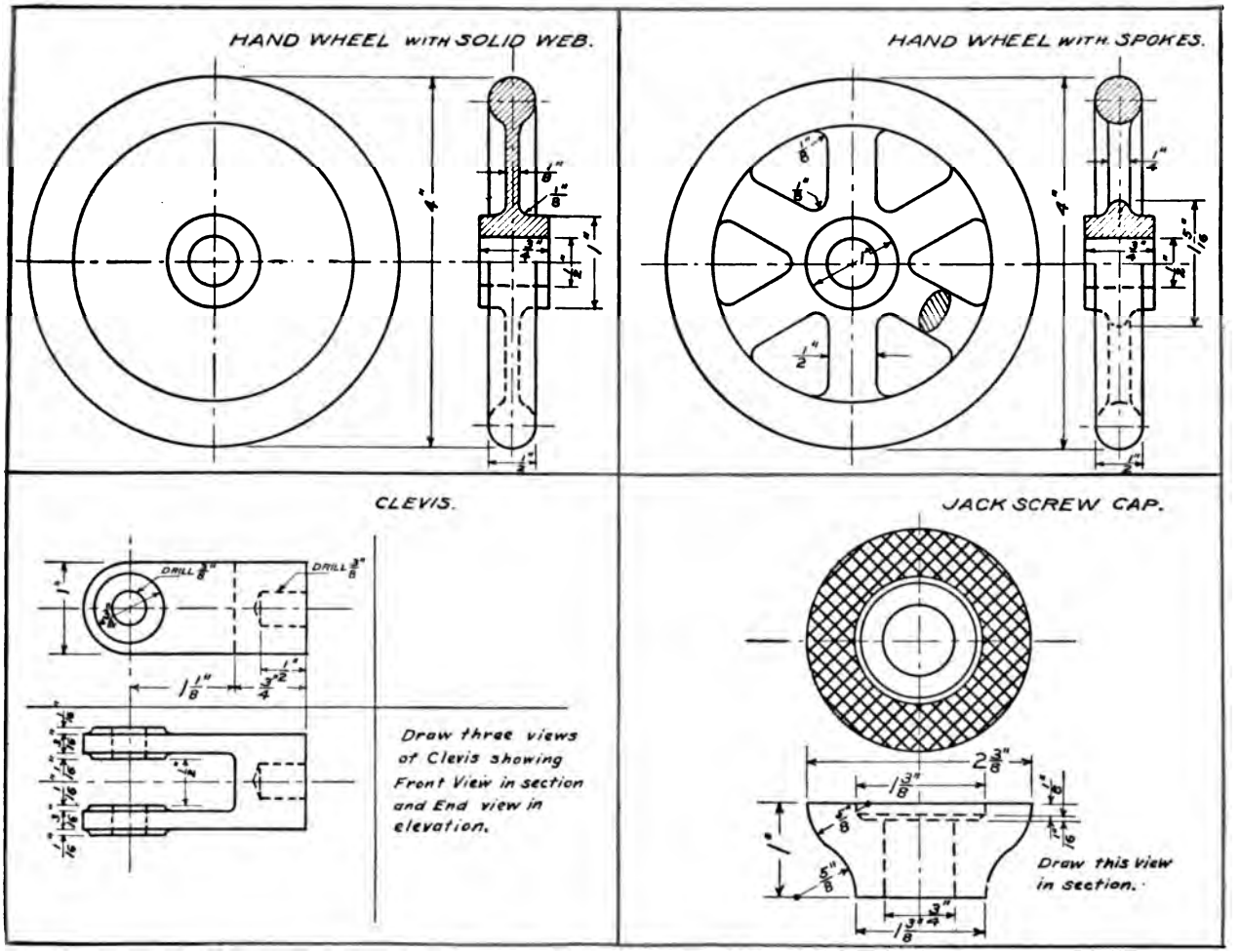


Fig. 66.

SECTIONS OF SIMPLE OBJECTS—PLATE 4



APPLICATIONS OF SECTIONS—PLATE 5



THE AUXILIARY PLANE.

It is often necessary to draw a foreshortened surface as though seen through a special or auxiliary plane which is parallel to the surface, as the boy is doing in Fig. 68.

Fig. 68

Fig. 69

The next picture, Fig. 69, shows all the planes lying flat, thus showing the relation of the auxiliary plane to the other three.

Fig. 70 is a mechanical drawing of Fig. 69 and

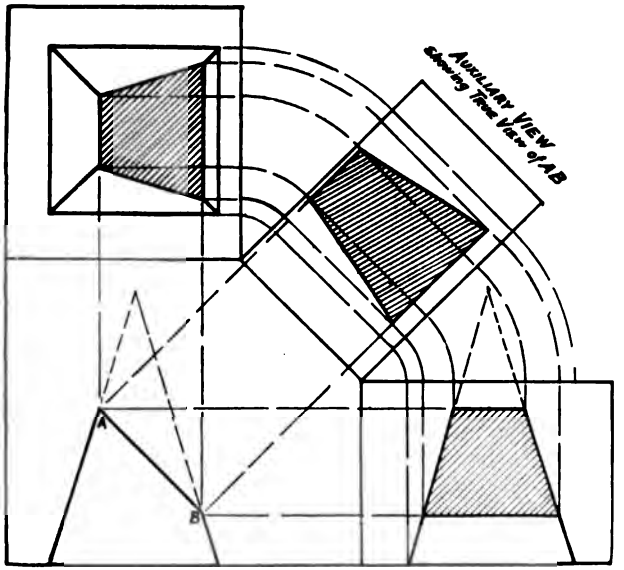


Fig. 70

shows clearly all the views and how they are projected across to each other.

In the auxiliary view, where do we get the distance from the top to the bottom? From side to side? Are there any other foreshortened surfaces in the three views?

When this method is clearly understood, auxiliary views may be drawn without projecting from the top or side views, these distances being obtained from either view by means of dividers.

In Fig. 71 we see how the auxiliary view A′B′C′ is found by simply drawing the base line X at any convenient distance from the oblique surface ABC, but parallel to it, and then with the dividers laying off the points A′B′C′ corresponding to the same distances in the top view.

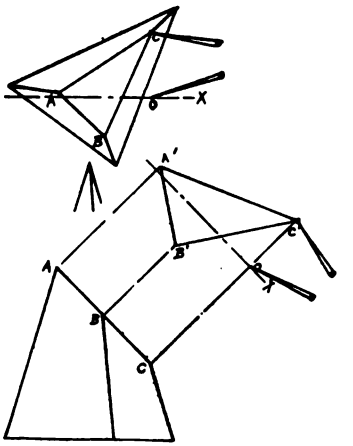


Fig. 71

This object is described as an irregular triangular pyramid whose top surface has been cut off at an angle of 45 degrees to the horizontal.

FINDING TRUE LENGTHS

Everything we look at is in one of two positions.

(1) Square in front, which gives a true view.

(2) At an angle, which gives a foreshortened view.

On the opposite page are several objects which have inclined faces, the problem being to find the true view of these faces.

Before starting to draw be sure to read and answer the following questions:—

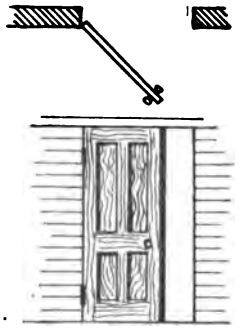


Fig. 72.

In Fig. 72, why does the door look narrower than the doorway?

What must we do to the door to show it in its true size?

In the aquarium, Fig. 73, are two fish, A and B. In the front view make a line under the fish that you think is the longest. How do you know it is?

What must the fish that is foreshortened do to show its true length in the front view?

Where must we stand to see the true length of fish C?

From studying these examples, is it clear that to get the true view of a foreshortened line or surface we must revolve it parallel to either the Top, Front, or Side projection plane?

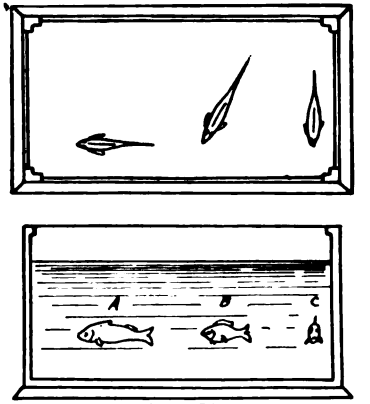


Fig. 73.

In Fig. 74 we see an application of this principle. It can be used with simple figures and is the quickest way to find the true view of a foreshortened surface. Can you tell which is the foreshortened view of the sail and which the true view? Notice that the vertical distances on the sail remain the same but the distances from side to side are changed.

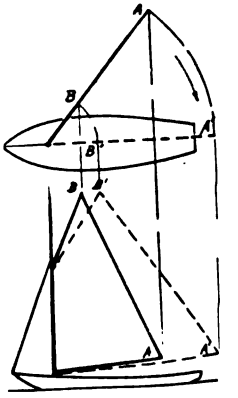


Fig. 74.

THE DEVELOPMENT OF SURFACES.

When the surface of a cylinder is unrolled, it becomes a rectangle whose length is equal to the circumference of the cylinder. This length can be calculated by mathematics, but it is usually found by dividing the circumference into twelve or more parts and then with the dividers laying off these parts along the above mentioned rectangle. (See Fig. 75.)

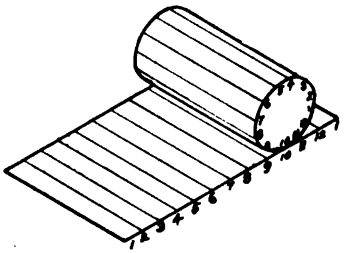


Fig. 75.

These lines which lie in a curved surface are called elements and, in determining given points are as necessary as the latitude and longitude lines on the surface of the earth. Fig. 76 shows how the elements of a cone are laid out to find the development.

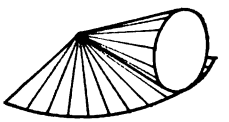


Fig. 76.

Objects that are made out of thin material such as cardboard, paper or tin are first drawn so that all the faces are in their true size and joined together in one piece. This is called the development of the object.

To test a development transfer it to another sheet and cut it out. If all the edges meet nicely, they can be pasted together by using small flaps.

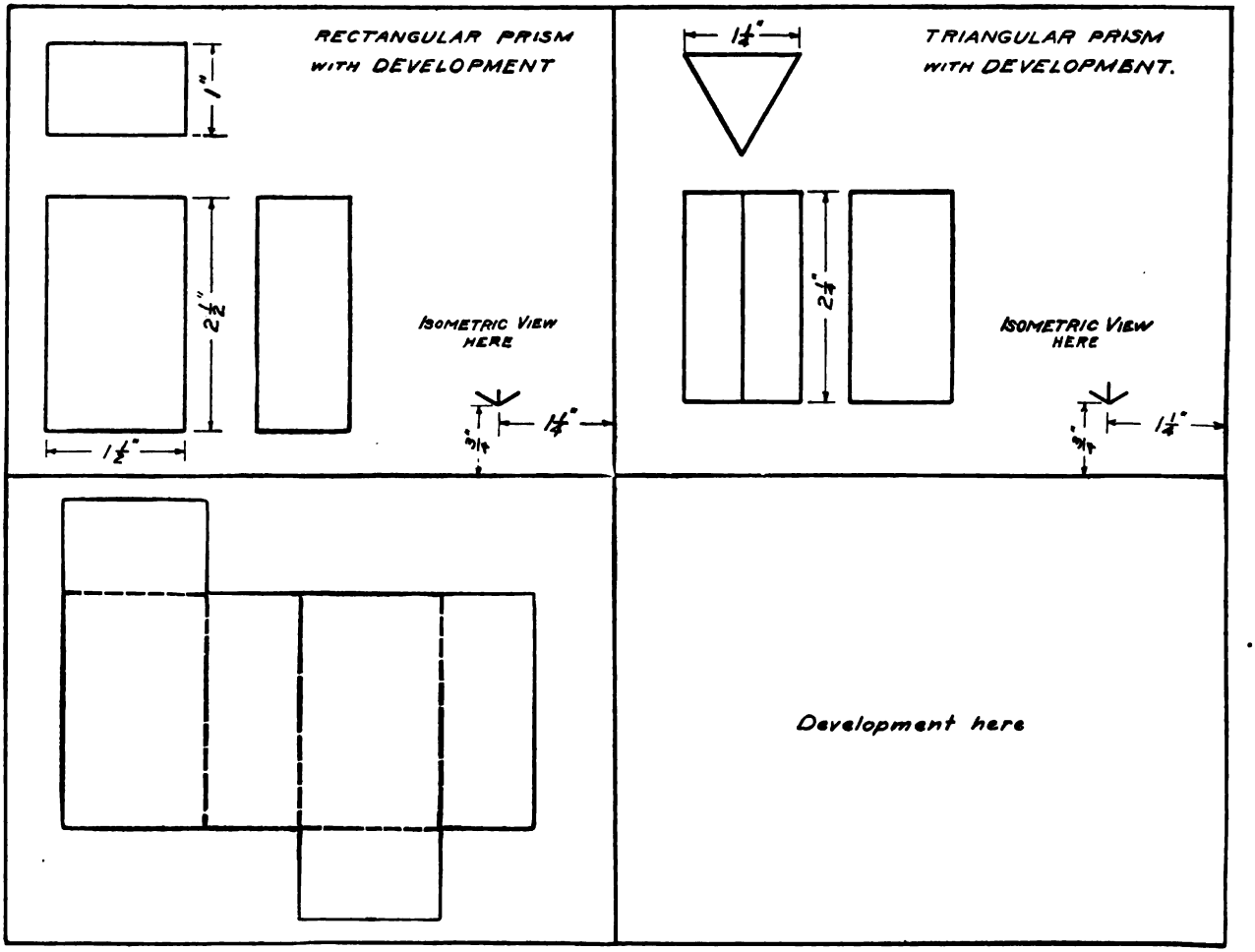
Plates 6-10 with their projections, isometric views and developments are each complete studies of the objects shown. When copying the projections letter all corners. Also show hidden edges in the isometric views. Letter all corners on developments and isometric views to correspond with projections.

In Plate 9, box in or "crate" the square pyramid in a cone as suggested in the top view. The four edges are equal, being elements of the cone as well as edges of the pyramid.

In the rectangular pyramid instead of drawing a complete cone as for the square pyramid, show only the portion used and find true length from that. Edge OA has been revolved from OA to OA1.

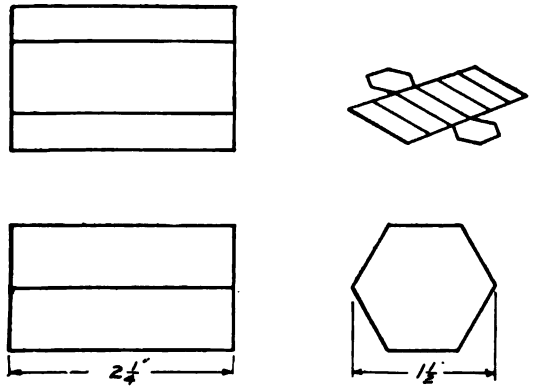
Suggestion:—These problems may be drawn double size and one on a sheet.

PROBLEMS IN DEVELOPMENT—PLATE 6

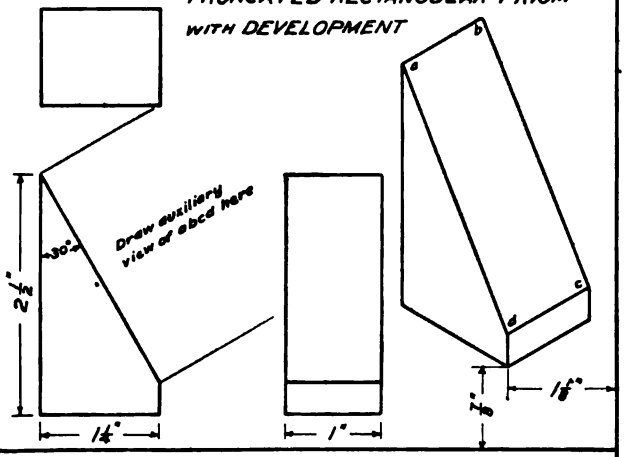


PROBLEMS IN DEVELOPMENT—PLATE 7

HEXAGONAL PRISM WITH DEVELOPMENT



TRUNCATED RECTANGULAR PRISM WITH DEVELOPMENT

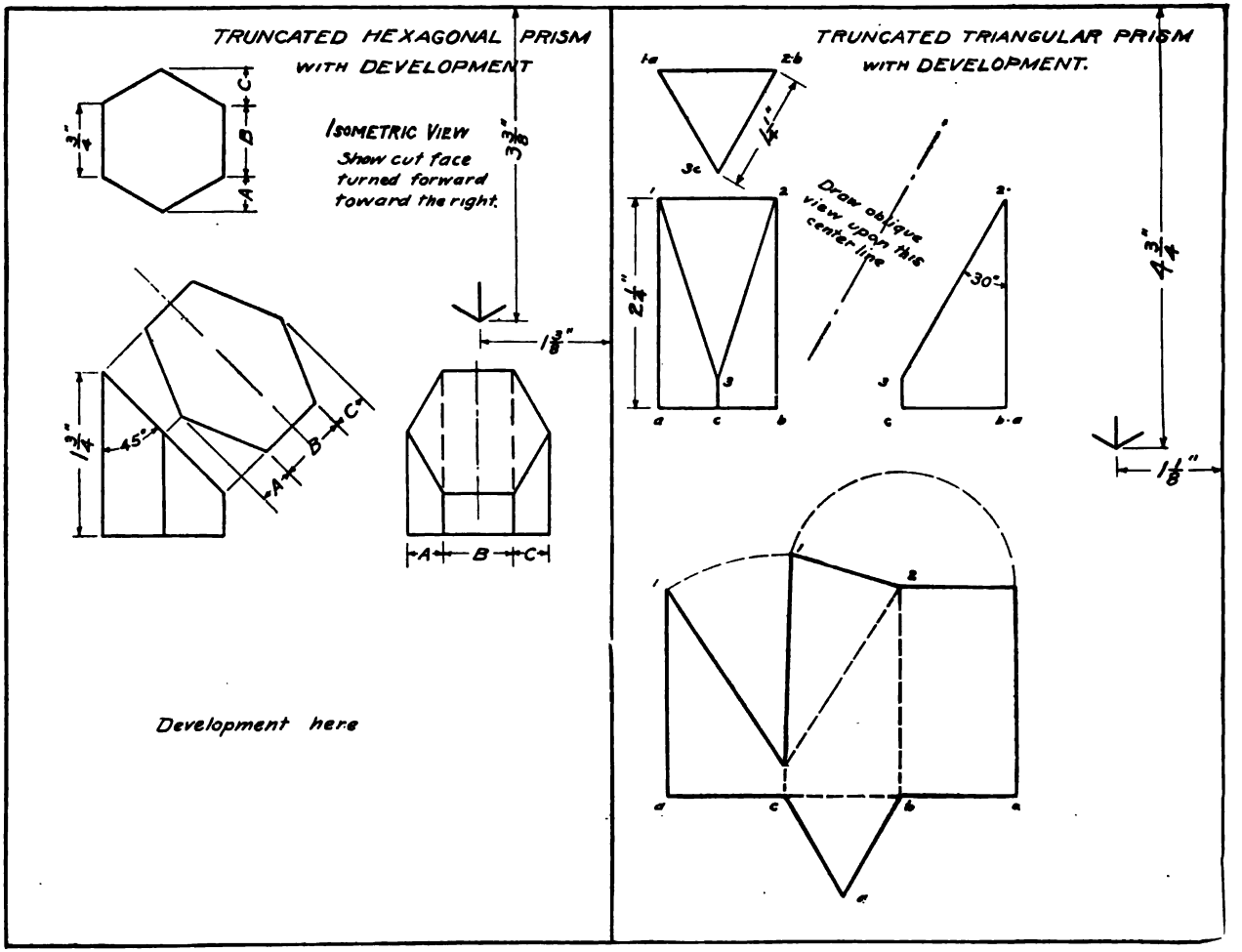


Development here

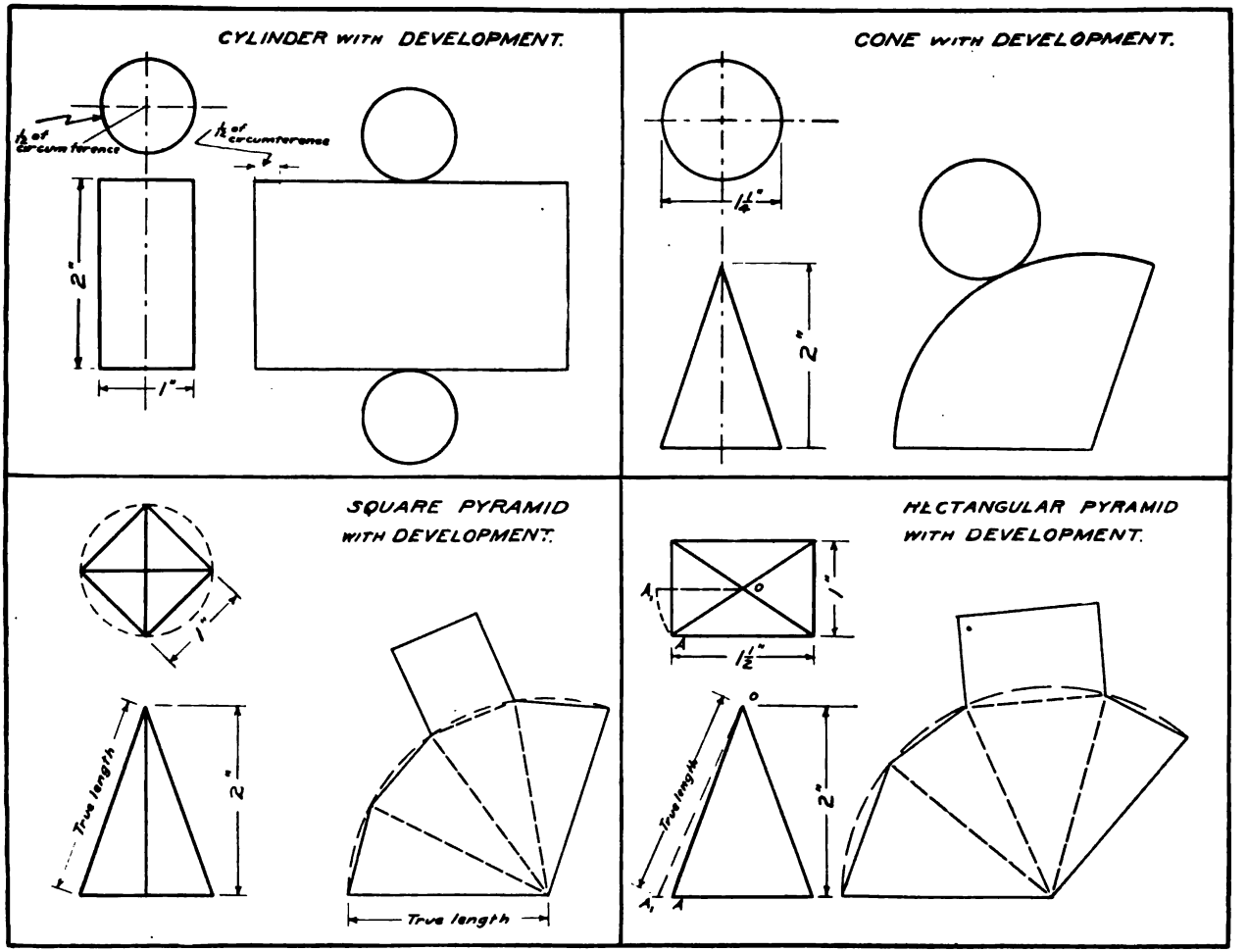
Development here.

Letter all corners of solid in projections and development, also indicate hidden edges in Isometric View.

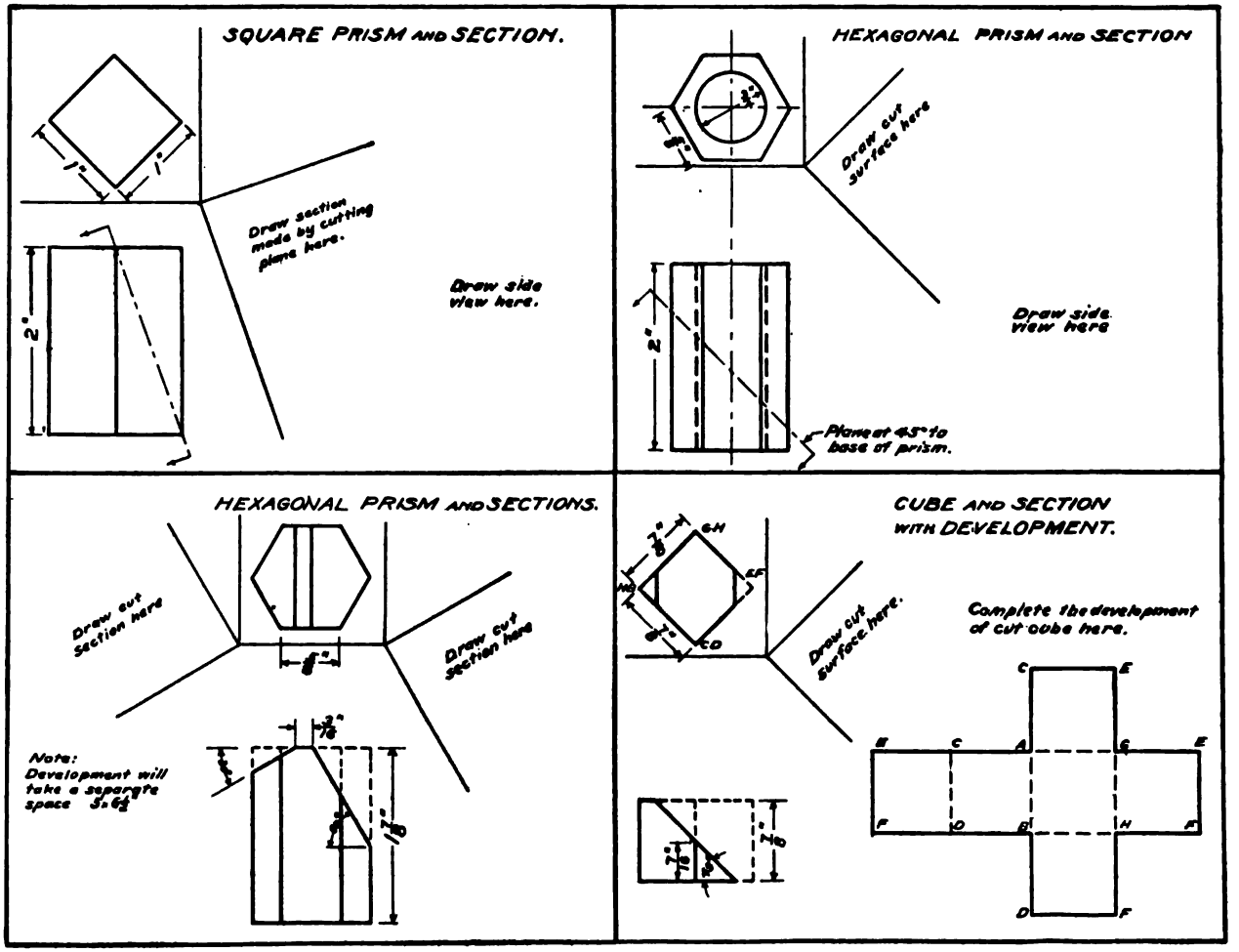
PROBLEMS IN DEVELOPMENT—PLATE 8



PROBLEMS IN DEVELOPMENT—PLATE 9



AUXILIARY VIEWS—PLATE 10



TEST PROBLEMS.

1. What is the shape of the section cut from a square prism by a plane passed at an angle of 45 degrees to the axis of the prism? Plane does not cut base of prism.

(2) Shape of a similar section passing through a cylinder?

(3) How do the sections made by planes passed parallel to the base on cones and cylinders compare? How do oblique sections of cones and cylinders not cutting the bases compare in shape? Give name of section cut in each case.

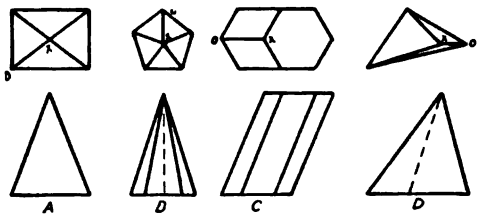


Fig. 77.

(4) A cone is cut by two planes each of which cuts the base of the cone. The first is passed parallel to an element of the cone; the second parallel to the axis. Will the cut sections be similar? What are they called?

5. Show the axis of the following solids. (Fig. 77). Which is oblique? Which is vertical?

6. Tell whether the edge (OX) shows in its true size or is foreshortened in Fig. A, B, C, D.

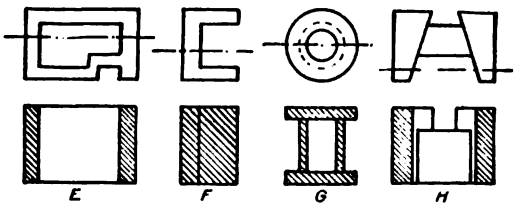


Fig. 78.

Give reasons in each case. Also where foreshortened. How do you find the true length?

7. Which sections are correct? E, F, G, H. (Fig. 78). Where wrong? Why wrong?

8. In each case show by section lines in the

top view where the section in the front view was made. (Fig. 79).

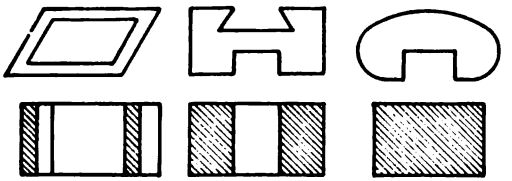


Fig. 79.

9. Name the solids which are represented by these developments. (Fig. 80).

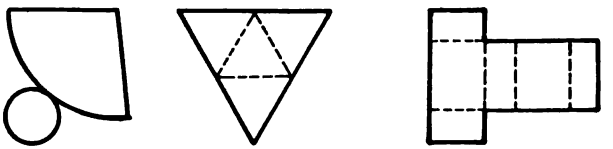


Fig. 80.

CONIC SECTIONS.

A regular cone may be cut by planes in four different directions each one producing a curve of definite shape and having a special name. They are as follows: (Fig. 81).

A, cut perpendicular to the axis forming a circle.

B, cut oblique to the axis forming an ellipse.

C, cut parallel to an element, forming a parabola.

D, cut parallel to the axis, forming an hyperbola.

The next two plates show clearly how these sections are drawn and their developments are well worth finding.

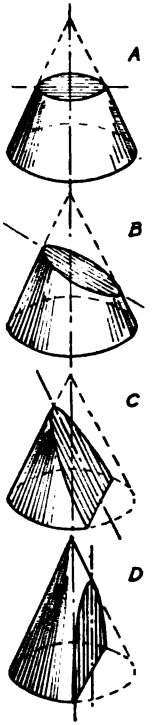


Fig. 81.

PLATE 11

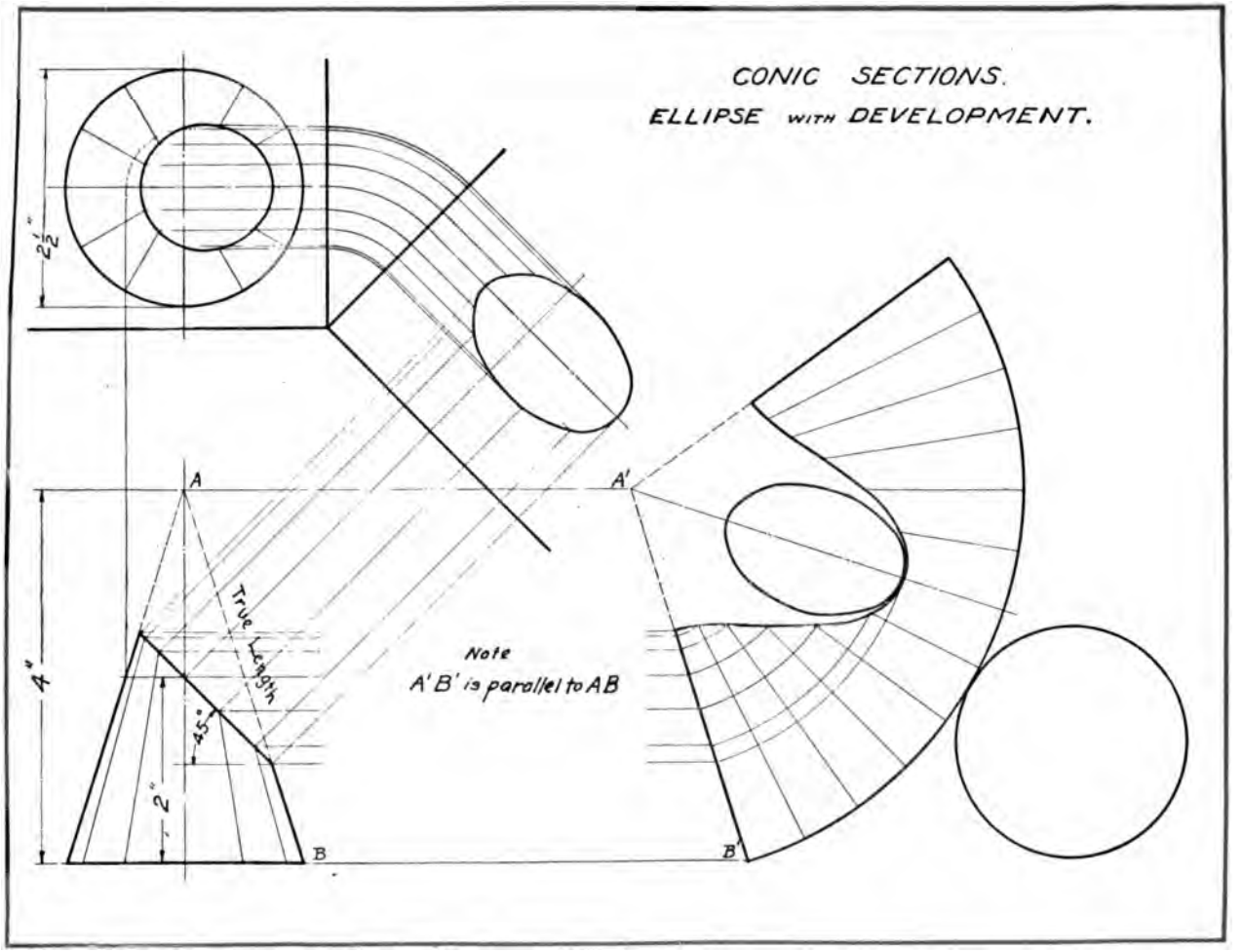
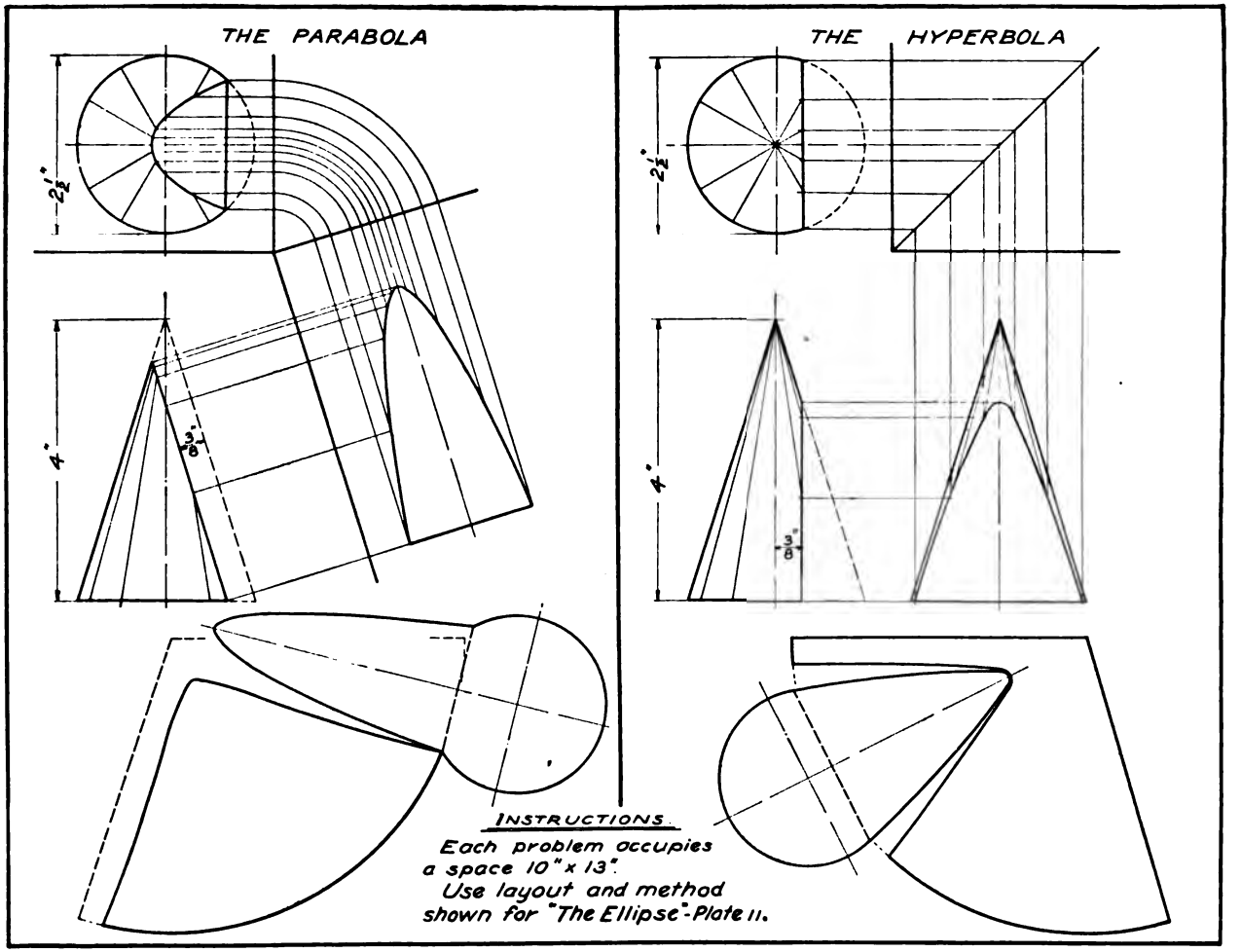

CONIC SECTIONS.
ELLIPSE WITH DEVELOPMENT.
2½"
A
A'
4"
True Length
45°
2"
B
B'
Note
A'B' is parallel to AB

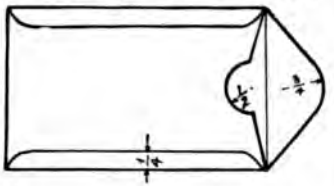
PLATE 12


THE PARABOLA
THE HYPERBOLA
2½"
4"
INSTRUCTIONS
Each problem occupies a space 10" x 13".
Use layout and method shown for "The Ellipse"-Plate 11.

SUPPLEMENTARY PROBLEMS IN DEVELOPMENT

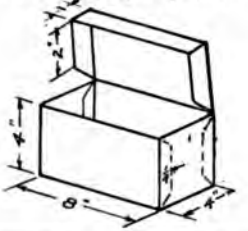
REPORT CARD ENVELOPE

To be made $\frac{1}{2}$" larger than Report Card



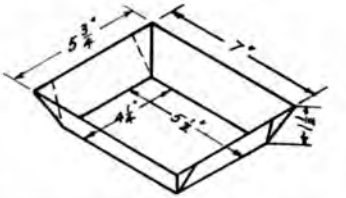
LUNCH BOX

Can be drawn half size



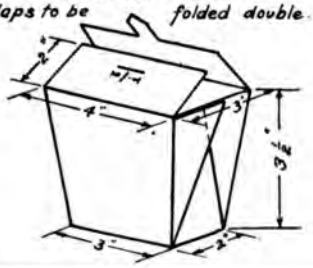
TIN TRAY

Draw three views & development

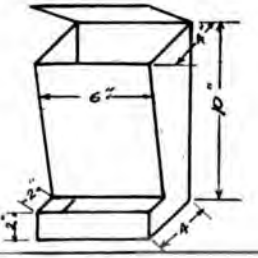


PAPER PAIL

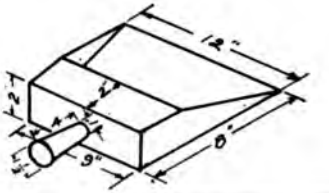
Flaps to be folded double



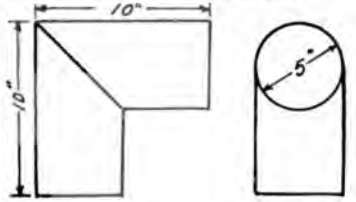
POULTRY FEED BOX



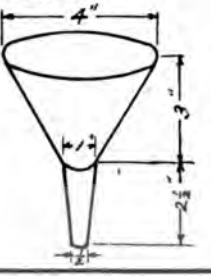
DUST PAN



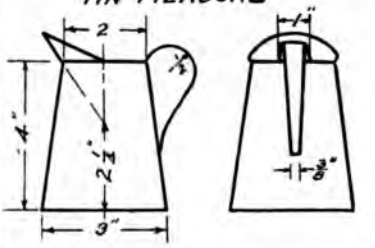
STOVE PIPE ELBOW



FUNNEL



TIN MEASURE



FREEHAND SKETCHING.

There are two good reasons why a draftsman should be able to sketch readily.

(1) He may desire to express an idea having only a piece of paper and a pencil at hand, or (2) he may be required to make a mechanical drawing of an object which cannot be taken to the drafting room. Hence the necessary data must be furnished by working sketches. To sketch readily requires a good eye and a steady hand. For this reason do not use a scale or ruler as all measuring on the drawing is to be done only by the eye. Do not be discouraged if your first efforts seem crude. It may be necessary to do some of the exercises more than once, but if each step is done carefully improvement will soon be noticed.

Use a 2-H pencil well sharpened and bear on it lightly at first.

Have an eraser handy and show only good lines. Anyone can make a poor line.

To the teacher:—A high standard in marking these plates is essential as the student, having become used to instruments, is not likely to exert himself when working without them.

DIRECTIONS FOR LAYING OUT THE OPPOSITE PAGE.

First draw lightly the line AB and divide it into halves and quarters. This will help in locating the 2″ squares.

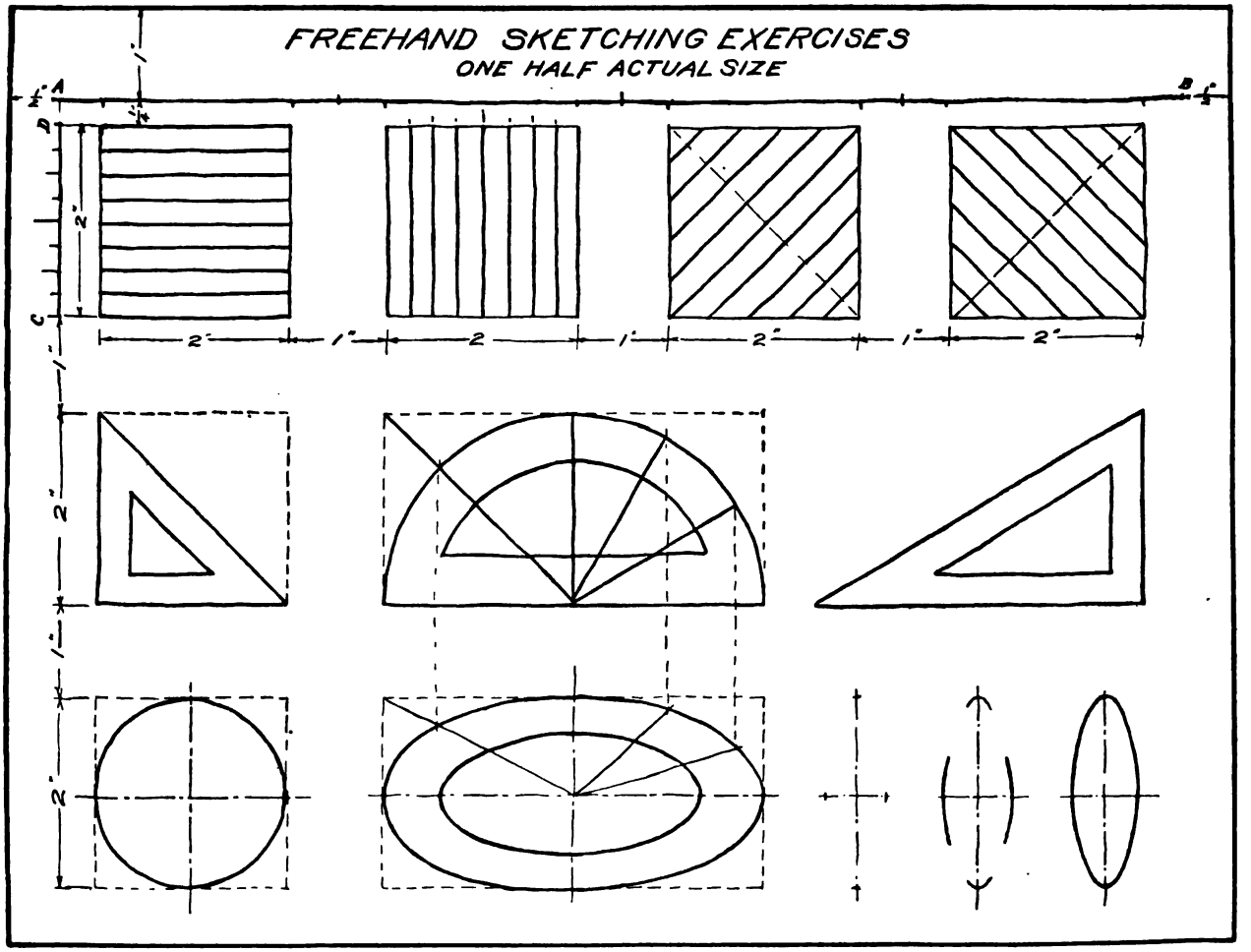
Do the same with the line CD and also the dotted diagonal in the two right hand squares.

Note carefully in the other figures, the center lines and light construction lines. They are just as important as the scaffolding on a building. **Never try to work without them.**

Learn the three steps in drawing an ellipse.

The large ellipse is a foreshortened circle. Notice how the 30 degree and 45 degree angles are also foreshortened.

PLATE 13


FREEHAND SKETCHING EXERCISES
ONE HALF ACTUAL SIZE
A
B
C
D
1"
2"
2"
1"
2"
1"
2"
1"
2"
2"
1"
2"

PRINCIPLES OF FREEHAND DRAWING.

(1) When making working sketches use the same method as in Orthographic or Projection drawing. Try to estimate the distances accurately so that the proportions will be as nearly like those of the object as possible.

(2) When making a pictorial view the simplest way is to sketch the object as though it were placed below the eye and a little to one side. (Fig. 82). Notice that side A is a regular front view and that sides B and C are foreshortened about one-half and inclined at an angle of 45 degrees.

This is called Cabinet Projection.

(3) When the object is placed below the eye and both sides are inclined equally from the line of sight the result is seen in Fig. 83. This is called Isometric Sketching, and is a little more like the true view of the object.

For buildings, interiors, and objects having much depth the Perspective method is used.

Cylinders and cones may be crated as in Fig. 84, but this labor may be saved if we notice that the long diameter of the ellipse is always at right angles to the axis or center line of the cylinder. Hence in sketching a round hole or cylinder be sure to locate the axis first so that the ellipse can be correctly drawn. Does the glass of water in Fig. 85 look right? What is the matter with it? Fig. 86 is the end of a gun barrel. In what direction will the bullet go? How do you know?

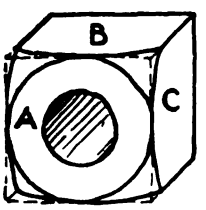


Fig. 82.

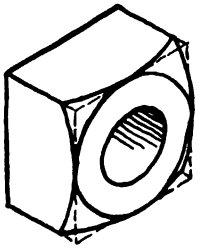


Fig. 83.

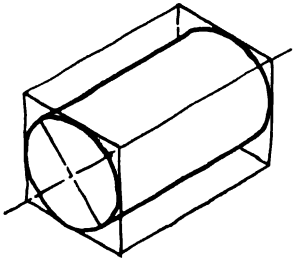


Fig. 84.

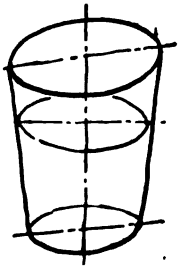


Fig. 85.

Fig. 86.

PLATE 14

MAKE CABINET SKETCHES OF THESE OBJECTS.
DO NOT COPY THESE PROJECTION DRAWINGS.

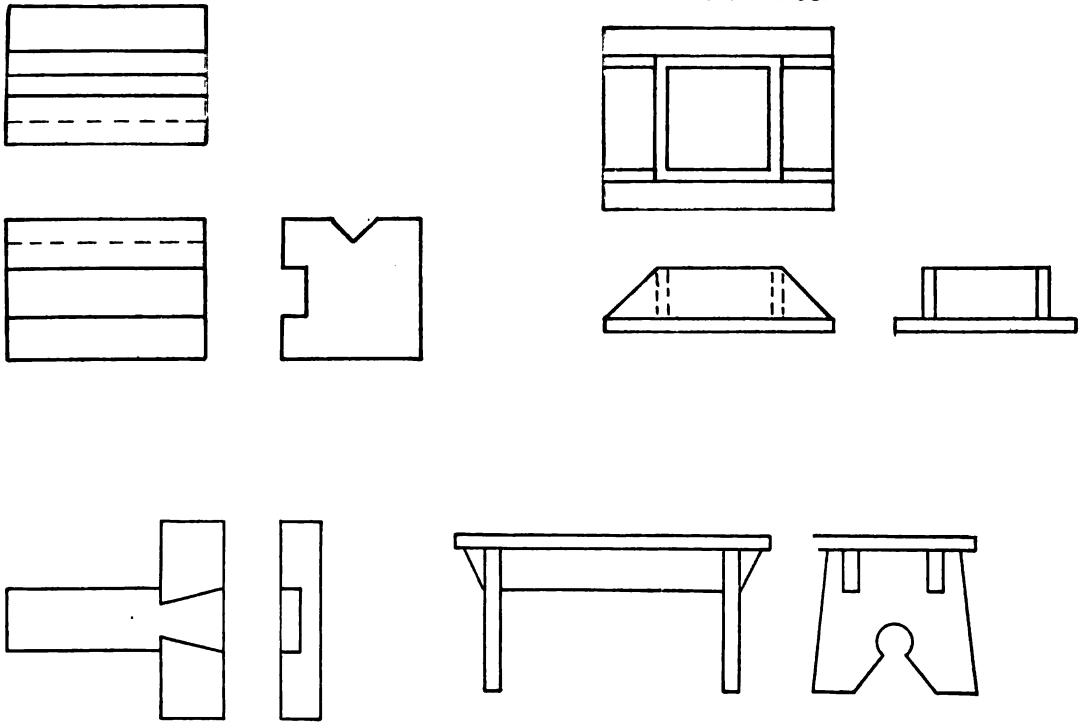
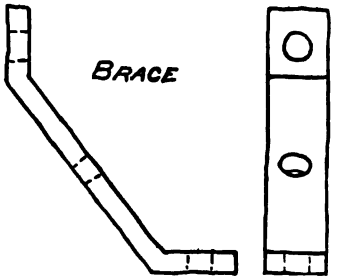
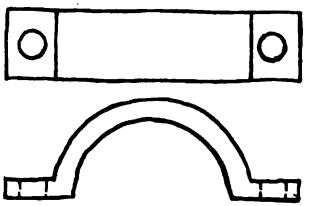
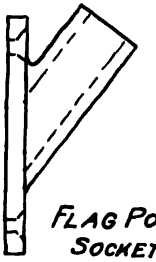


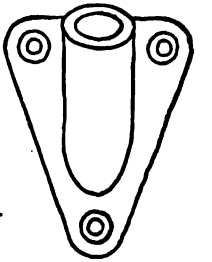
PLATE 15

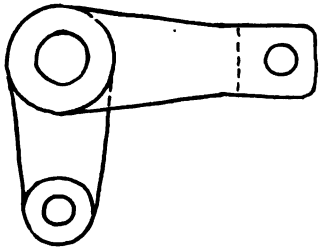
DRAW ISOMETRIC SKETCHES OF THESE OBJECTS.

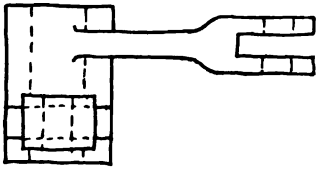




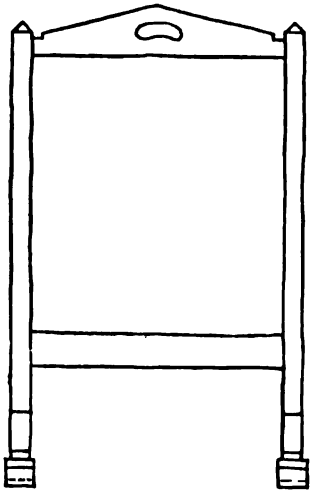




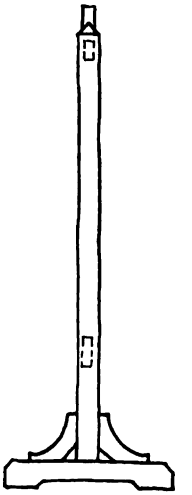


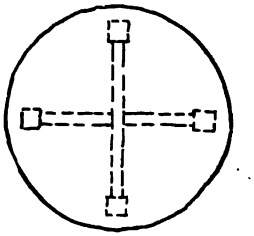


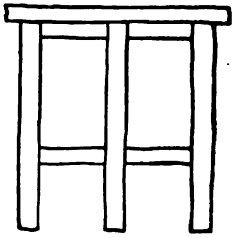
BELL CRANK



FIRE SCREEN







TABORET